# Notes

Atomic Energy Control Board | Commission de contrôle de l'énergie atomique

**INFORMATION BULLETIN 88-1** March 15, 1988

**REGULATORY RESEARCH & SUPPORT PROGRAM FOR 1988/89 -- PROJECT DESCRIPTIONS**

The Regulatory Research & Support Program is intended to augment and extend the Atomic Energy Control Board's regulatory program beyond the capability of in-house resources. The overall objective of the research & support program is to produce pertinent and independent information that will assist the Board and its staff in making correct, timely and credible decisions on regulating nuclear energy.

The program is divided into eight main areas of research covering the safety of nuclear facilities, radioactive waste management, health physics, physical security and the development of regulatory processes. A total of 79 projects are planned for 1988/89, including a number which are ongoing from the previous fiscal year. Projects that are held in reserve in case funding becomes available are also listed.

Most of the projects will be carried out under contracts issued through the Department of Supply and Services.

This Information Bulletin contains a list of the projects with a brief description of each, and additional supporting information.

A document describing how the AECB Regulatory Research & Support Program is administered (INFO-0157/Rev-1) has been incorporated into this Bulletin. Additional copies of this Bulletin, or other information concerning its contents, may be obtained by contacting.

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# REGULATORY RESEARCH & SUPPORT PROGRAM 1988/89

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*New = as of 1987-88 program year.
Old = 1986-87 program year or earlier.

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REVISION 1
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# THE ATOMIC ENERGY CONTROL BOARD'S

# REGULATORY RESEARCH AND SUPPORT PROGRAM

OBJECTIVES

1. The purpose of the Regulatory Research and Support Program is to augment and extend the capability of the Atomic Energy Control Board's (AECB) regulatory program beyond the capability of in-house resources. The overall objective of the program is to produce pertinent and independent scientific and other knowledge and expertise that will assist the AECB in making correct, timely and credible decisions on regulating the development, application and use of atomic energy.

2. Within the framework of the general objective, the specific objectives are to obtain knowledge and expertise with which to:

   (1) verify information, claims or analyses from licensees in support of licensing actions;

   (2) enable the AECB to contribute to the establishment of health and safety requirements, standards or guidelines;

   (3) stimulate licensees to do more work on certain topics relating to health, safety, security or protection of the environment;

   (4) help to improve the AECB's regulatory process and the evaluation of the regulatory process;

   (5) develop equipment or procedures to enhance health, safety, security or protection of the environment in those cases where the industry is not required to do so;

   (6) develop sources of knowledge and expertise outside the AECB on which the AECB may draw; and

   (7) enhance the competence of the AECB and thus its credibility in the eyes of licensees and the public.

NATURE OF THE PROGRAM

3. The objectives are achieved through contracted research, development, studies, consultant and other kinds of projects administered by the Research and Radiation Protection Branch (RRB) of the AECB.

4. The program is mission-oriented and intended to contribute to achieving AECB objectives, directly or indirectly. There must be linkage between a project and other AECB activities and their objectives. Although projects may produce results which are of use to others outside of the AECB, this is a secondary consideration.

5. Projects relate to:

   (1) setting AECB regulatory requirements, standards and guidelines, including standards set by others which are directly or indirectly of benefit to advancing AECB objectives;

(2) licensing, inspection or enforcement activities;

(3) assessment of information, particularly information submitted to the AECB in connection with licensing, inspection or enforcement activities; and

(4) regulatory process development, including certain administrative activities to improve the efficiency and effectiveness of AECB regulation.

6. Because of the broad scope of each of the above activities, some projects may relate to more than one of the above activities.

7. Projects are designed to meet AECB needs. Outputs may range from having an immediate, direct and short-term application to solving a specific problem, e.g., to assist in assessing a submission, to making a general, indirect and long-term contribution to solving a part of a more general problem, e.g., an epidemiological study on some aspect of radiation dose or exposure which may eventually contribute to setting a standard regarding such dose or exposure.

8. The program may be used to enable the AECB to participate in a project sponsored by others, with the degree of AECB interest reflected in the level of AECB funding.

9. Contracting of AECB projects is done in accordance with the federal government's Contracting-out Policy, usually through the Department of Supply and Services (DSS).

## PROGRAM PLANNING AND DESIGN

### The Planning Cycle

10. In August, the RRB issues a call to other AECB staff, and to interested parties external to the staff, for proposals for the coming fiscal year, which begins on April 1 (referred to hereafter as the program year).

11. During October and November, staff of the Research sections meet with proponents to develop the project proposals. The program is compiled from these proposals, from projects continuing or brought forward from the current year, and proposals which have been received during the course of the year.

12. From their discussions with proponents, the Research sections of the RRB obtain some idea of priorities and divide the proposals into those which are planned for the upcoming year within the available budget and those which will be held in reserve pending the availability of funds. The resulting preliminary version of the program is reviewed with the senior management of AECB staff and then with the Joint Sub-committee on Regulatory Research (JSCRR) of the two advisory committees to the Board (the Advisory Committee on Nuclear Safety and the Advisory Committee on Radiological Protection). The final version for submission to the Board is then prepared.

13. From the detailed list of projects which emerges from the above process, the RRB prepares a Board Member Document describing the program and funding by mission object (see paragraph 25).

14. The Board Members consider the proposed program at their January meeting, at which they also receive advice directly from the two advisory committees to which the JSCRR has reported. The Board Members arrive at their decision and, if necessary, the program is modified and resubmitted to the Board Members at their next meeting.

15. The final list of Project Summaries (see Appendix A) is printed, distributed to interested parties outside the AECB and made available to the public, usually in early spring, by means of an information bulletin and by being listed in the AECB's catalogue of publications.

16. Since the program is designed to respond to the short-term as well as the long-term needs of the AECB, the program is open to changes during the course of the program year. Planned projects are cancelled if circumstances which led to the original proposal change; new projects are introduced if new needs arise. The dynamic and flexible nature of the program is key to the usefulness of the program to support other AECB activities.

17. Although the call for proposals is made in August, proposals from both Board staff and other sources can be considered during the course of the year (category NEW). Whether NEW proposals are incorporated into the program depends on the priority assigned to them relative to other projects. Those NEW projects which are not acted upon in a given year are carried forward for consideration for the following year's program.

Sources of Proposals

18. Proposals for projects within the AECB may come from:

    (1) Board Members;

    (2) Advisory committees; and

    (3) Board staff, usually from a division or higher level.

19. Proposals may also come from sources outside the AECB, such as:

    (1) Unsolicited Proposals from organizations or potential contractors outside the AECB;

    (2) other federal or provincial departments or agencies; and

    (3) recommendations from public hearings, enquiries or commissions.

    Proposals from outside the AECB must have the support of an AECB division, branch or directorate concerned with the use of the results.

## Selection of Proposals

20. Proposals are screened for their relevance to the AECB program and then divided into categories according to priorities.

## Screening Criteria

21. The following criteria are applied to decide which proposals are worthy of consideration for AECB support:

    (1) the proposal must be relevant to the objectives of the program;

    (2) there must be justification for the AECB to undertake the proposal as a support project as opposed to, for example, expecting or requiring the work to be done by licensees or the Board staff; and

    (3) work done elsewhere should not be duplicated unless the purposes of the proposal include a verification or validation of the other work.

## Priorities

22. The establishment of priorities for the initial draft of the program is based upon the following factors, listed in order of importance:

    (1) the urgency with which information may be needed;

    (2) the importance of the information to the relevant AECB activity;

    (3) the degree or extent of the lack of knowledge of a hazard in a particular situation, where worker or public health or safety may be perceived to be adversely affected by the operation of a nuclear facility or the use of a prescribed substance;

    (4) the expectation that several sources of demand will be accommodated by the results of a single project;

    (5) the expectation that a project may provide a high return of knowledge to the AECB for a small expenditure, such as may be achieved through cost-sharing ventures with other organizations;

    (6) the funding of projects of a continuing nature, where the contractor has demonstrated competence, over those projects which are new in concept or where the contractor is largely unknown to the AECB; and

    (7) the requirement to spend funds in Canada to the extent possible and where economic benefit and transfer of technology to Canadian industry is maximized.

23. The project proposals are initially divided into categories as follows:

    (1) category 1*- projects which are continuing from the year prior to the program year;

    (2) category 1 - those planned to be initiated in the program year;

(3) category 2 - projects which would be category 1 but whose initiation depends on the outcome of other work, such as a feasibility study;

(4) category 3 - projects which are worthy of support but for which funds are not available; and

(5) category 4 - projects which should not be supported.

24. The final setting of priorities before submitting the program to the Board for approval is determined by the senior management of the Board staff taking into account comments from the JSCRR. These priorities are largely determined through discussion and negotiation. Category 4 items are not included in the final document.

Structure of the Program

25. Since the program is intended to support AECB activities, it is divided into "mission objects" as follows:

| Mission Object Number* | Object |
|---|---|
| 2 | Nuclear reactors |
| 3 | Fuel cycle facilities, general |
| 4 | Uranium mines and mills |
| 5 | Waste management |
| 6 | Non-fuel cycle applications |
| 7 | Health physics |
| 8 | Transportation |
| 9 | Regulations and regulatory process development |

PROGRAM IMPLEMENTATION

Project Initiation and Approval

26. A Project Manager from one of the two sections that administer the program is assigned to each project to act, in DSS terminology, as the "Scientific Authority" for the eventual contract (some projects may involve more than one contract). A Technical Adviser, usually someone from the proponent division of the AECB staff, may be identified who acts

*Since the mission object number is used in the AECB filing system, and the numeral "1" is used for another program, the mission object numbering begins with "2".

as an adviser or an authority (i.e., expert) on the technical aspects of the project. The Technical Adviser will, therefore, usually also be an Evaluator. Other Evaluators are identified as needed.

27. In consultation with the project proponent, the Project Manager prepares a Proposal for an AECB Support Project and a Statement of Work describing the project in detail. Comments on this material are obtained from appropriate Directors General, Directors and Managers.

28. Projects costing more than $100K are submitted to the Board Members for approval, those costing $50K to $100K are approved by the President, and those costing less than $50K are approved by the Director of the RRB. For this purpose, the cost of all directly-related projects must be taken into account, e.g., the cost of a feasibility study would have to be included with the cost of a follow-on experimental investigation for the purpose of deciding on the approval level for the latter.

29. The initiation of all contracts is routinely reported to the Board Members in the Significant Development Report for each Board meeting.

External Review

30. Review panels may be formed for some individual projects or groups of similar projects based on considerations of:

    (1) cost;

    (2) complexity;

    (3) whether the area of activity or discipline is new to the program;

    (4) whether ethical considerations are involved (e.g., studies involving human data or experiments involving animals); and

    (5) whether a number of projects, which fall into a similar group or subject area, would benefit from a panel review.

31. Since panels involve a significant expenditure of AECB staff resources, this factor can limit the number of projects designated for review by panels.

32. Review panels will usually be involved in the review of a project from the preparation of a statement of work through to participation in the post-project evaluation. Panel size and composition may vary from one to a dozen members, will usually include independent members as well as AECB staff and be national or international in scope. The Project Manager acts as the convenor of the panel.

Contracting

33. When approval has been given to initiate a contract, two forms, an Internal Requisition and an Expenditure Initiation for an AECB Contract/Agreement, are prepared for the Finance Section to commit the necessary AECB funds for the current fiscal year.

34. The total cost for a proposed contract may be set as a ceiling price by the AECB or may be tentatively accepted, subject to negotiation, as part of the complete proposal by the prospective contractor. The fees for the services of a contractor's personnel are set by DSS acting on behalf of the client department, as are overhead rates on both fees and certain expenses. For the most part, expenses are charged at cost. DSS determines from the contractor that the rates of pay charged to the client department do not exceed those charged to most-favoured clients.

35. The legal aspects of the agreement between the contractor and the AECB are contained in the DSS contract which provides all the relevant information on the Scientific Authority, the Science Procurement Manager within DSS, cost, statement of work, duration, progress reporting sequence, delivery dates and deliverables as well as all the standard general terms and conditions of the agreement. It is stipulated in the contract that the contract supersedes all other commitments, oral or written, between the contractor and the AECB. A requirement for an ethics review is included if the project includes studies using human data or animal experiments.

36. Once a detailed Statement of Work has been prepared, a list of potential contractors is supplied by DSS using its Science Procurement Information Network (SPIN) which, based on a keyword approach, gives the capabilities and areas of expertise of potential contractors. The RRB also maintains its own lists of contractors with particular expertise. A final list of potential bidders is prepared by the Science Procurement Manager at DSS in consultation with the Scientific Authority, after which a Request for Proposal (RFP) (which includes the Statement of Work) is issued to each potential bidder. Those bidders who respond to the RFP are judged on the basis of their understanding of the problem and response to it and on the quality of the personnel whom the bidder will devote to the project. In this process, the Scientific Authority consults other AECB staff, members of the review panel, if there is one, or other government departments, depending on the nature and type of contract. The successful bidder is then awarded the contract by DSS.

37. For contracts of less than $30,000, DSS may allow the "sole source" selection of a contractor by client departments. Such a procedure may be used to maintain continuity in a project consisting of several contracts or to expedite the issuance of a contract when the AECB staff consider, and DSS accepts, that the procedure is justified. On certain types of small contracts, mainly those related to professional services (as opposed to science and technology-related contracts as defined by Treasury Board), the AECB technical staff prepares its own agreements with the aid of AECB Legal Services and the Finance Section.

Execution of Contracts

38. The Scientific Authority maintains control over the contract and an awareness of the progress of the work through periodic progress reports, meetings with the contractor, correspondence and telephone communication with the contractor. Continued satisfactory progress by the contractor is attested to by the Scientific Authority, who is the only person to authorize payment of invoices. Normally, a holdback is retained on each payment to the contractor. The holdback is released when the contract is satisfactorily completed.

39. A draft final report is submitted by the contractor several weeks before the contract termination date to allow time for all interested AECB staff to review the work, in relation to the Statement of Work. A seminar is held at the AECB offices at which the contractor makes an oral presentation of the work to AECB staff, members of any applicable panel and staff of interested organizations including relevant licensees. The comments and corrections conveyed to the contractor are incorporated into the final report which is usually prepared within a few weeks of the seminar and before the contract termination date.

Reporting of Results

40. The receipt of a final contract report begins a number of actions to assess the results, conclusions and recommendations of the work and to communicate these findings to the proponent. Copies of the report are also made available to other interested AECB staff.

41. The RESULTS of completed contracts are reported routinely to the Board Members in the Significant Development Report for each Board meeting.

Publication

42. Most final reports which are received by the AECB under the program are published by the Office of Public Information. The exceptions are generally those reports which contain classified, protected or proprietary information. Each published document receives a number in the INFO series and is recorded in the AECB catalogue of publications, which is brought up to date and distributed quarterly. Any person or organization may be put on the mailing list for the catalogue. Copies of any document in the catalogue can be obtained on request to the AECB's Office of Public Information.

43. Contractors are encouraged to publish their findings in the open literature, acknowledging that the work was done under an AECB contract. They are further encouraged to participate in seminars and symposia, sometimes paid for through the contract. The AECB maintains a record of non-AECB publications resulting from a contract.

POST-PROJECT EVALUATION

44. For DSS purposes, a brief questionnaire on the performance of the contractor is completed.

45. For AECB purposes, a comprehensive Post-project Evaluation (PPE) is prepared consisting of four parts:

    (1) an evaluation of the contractor's performance;

    (2) a review of the actual use made of the results of the project, the effect on AECB or AECB-regulated activities and any contribution to the general body of scientific knowledge;

(3) recommendations, if any, for further work or further action; and

(4) an evaluation of the value of the results in relation to the cost ("value for money").

46. Parts (1), (2) and (3) are the responsibility of an evaluator identified when the project is initiated. There may be more than one evaluator, and evaluators may be appointed from inside or outside the AECB. If a panel exists, it provides input to the evaluation as well. Part (4) is the responsibility of the RRB.

47. For post-project evaluation, an initial questionnaire is completed within a few months of acceptance by the AECB of the final report or other product according to the terms of the contract. If necessary, follow-up questionnaires are initiated until sufficient information has been collected to complete the evaluation and draw the necessary conclusions. A summary of the results and conclusions of each project, when completed and evaluated, is stored in an information retrieval system for future availability or analysis. A project is not considered to be completed until the post-project evaluation has been completed.

## REPORTS

48. The program Board Member Document and the public list of projects are described in paragraphs 13 and 15 respectively. A report on contracts issued and completed is included as an appendix to the Significant Development Report which is prepared for each Board meeting (see paragraphs 29 and 41). Quarterly financial reports are prepared for internal use and quarterly status reports on projects are prepared for internal and external distribution.

### Annual Report

49. An annual report is prepared each spring, reviewed with the JSCRR and submitted to the Board Members at their September meeting.

50. The report contains an overview of the performance of the program during the fiscal (April 1 - March 31) year just completed, including any developments in the administration of the program, a review of activities by mission object, a list of review panels, their membership and activities and the project summaries (see paragraph 55). Since projects will continue to be reported until the PPE is completed, the annual reports are the one document in which completed project summaries are recorded.

APPENDIX A

THE PROJECT SUMMARY
(see paragraph 15)

51. The basic part of the project summary consists of a five-part description of a project:

WHAT — work is proposed and the means by which is it proposed to do the work, e.g., literature review, feasibility study, labortory experiment

WHY — the project is proposed, i.e., the justification for the project

HOW — it is intended to use the results

RESULTS — from the completed project

EVALUATION — of the use made, or likely to be made, of the results of the project and the value obtained for the money expended

52. The first three parts (WHAT-WHY-HOW) form the basis for a project when it is proposed. The following information is also included with each summary:

PROJECT NUMBER
- consists of three numbers; the first number is the number of the mission object (see paragraph 25)
- the second number is the item number in that mission object
- the third number is the phase number, since some projects are subdivided into phases (set to 1 even if there is only 1 phase)

TITLE

PROJECT MANAGER - (see paragraph 26)

PROPONENT - (see paragraphs 18 and 19)

EVALUATOR - (see paragraph 26)

CONTRACTOR - (see paragraphs 36, 37) contains an entry only if a contract has been let, e.g. for a project in progress at the beginning of the program year

CATEGORY - (see paragraphs 23, 24)

REVIEW PANEL - (see paragraphs 30 to 32) lists the code number of the panel, if there is one, otherwise "No" appears if there is not

FUNDING - shows actual AECB funding for past years and estimated AECB funding for the program year and future years

RELATED PROJECTS - directly-related projects, e.g. literature reviews, feasibility or pilot studies or earlier phases of a project consisting of more than one project in series (see paragraph 28)

53. When a contract for a project has been issued, the summary is reported to the Board in the Significant Development Report, together with the cost of the contract and the name of the contractor (see paragraph 29).

54. When a project has been completed, the project summary is reported to the Board in the Significant Development Report with the RESULTS part added (see paragraph 41).

55. Each project summary is included in the annual report (see paragraph 50), to the extent that the project has been completed, together with the following information:

PROJECT NUMBER - see paragraphs 52

TITLE

CATEGORY - see paragraphs 23, 24

CONTRACTOR - see paragraph 36, 37

SPENDING - shows the original estimate and actual cost

CONTRACT COMPLETION - "Yes", "No", or "N/A" ("not applicable") if no contract has been issued

COMMENTS - may indicate the status of an uncompleted contract or any significant changes or developments during the course of the project

EVALUATION - indicates status of the evaluation, if not completed, or the results of the evaluation

PUBLICATIONS - the AECB report number, if the report is not classified or protected, and any other publications of which the AECB is aware which resulted from the work

REVIEW PANEL ACTIVITIES - if there is a review panel, shows the code number and describes the activities of the panel and its influence on the project; left blank if there is no panel

APPENDIX B

## ABBREVIATIONS

AECB - Atomic Energy Control Board (see paragraph 1)

DSS - Department of Supply and Services (see paragraph 9)

JSCRR - Joint Sub-committee on Regulatory Research (see paragraph 12)

PPE - Post-project Evaluation (see paragraph 45)

RFP - Request for Proposal (see paragraph 36)

RRB - Research and Radiation Protection Branch (see paragraph 3)

SPIN - Science Procurement Information Network (see paragraph 36)

BMD/38

FUNDING OF AECB REGULATORY RESEARCH & SUPPORT PROGRAM

BY MISSION OBJECT

(FY 88/89 ALLOCATION: $2,799K)

| NO. | MISSION OBJECT | FY 88/89 ALLOCATION (K$) | | |
|---|---|---|---|---|
| | | CATEGORIES 1* & 1 & 2 | CATEGORY 3 | TOTAL |
| 2 | NUCLEAR REACTORS | 1,194 | 1,038 | 2,232 |
| 3 | OTHER FUEL CYCLE FACILITIES, GENERAL | 454 | 150 | 604 |
| 4 | URANIUM MINES AND MILLS | 505 | 400 | 905 |
| 5 | WASTE MANAGEMENT | 255 | 105 | 360 |
| 6 | NON FUEL CYCLE APPLICATIONS | 76 | 75 | 151 |
| 7 | HEALTH PHYSICS | 526 | 590 | 1,116 |
| 8 | TRANSPORTATION | 45 | 35 | 80 |
| 9 | REGULATIONS & REGULATORY PROCESS DEVELOPMENT | 117 | 50 | 167 |
| | TOTALS | 3,172 | 2,443 | 5,615 |

# LIST OF REVIEW PANELS FOR REGULATORY RESEARCH AND SUPPORT PROGRAM PROJECTS

1. RADIATION-INDUCED DEVELOPMENTAL DEFECTS

   Project Manager: V. Elaguppillai

   In Progress:

   Epidemiological Study of Radiation-Induced Developmental Defects (7.105.1)

   In Vitro and In Vivo Studies of the Effects of Ionizing Radiation on the Developing Central Nervous System (7.111.1)

2. EPIDEMIOLOGY

   Project Manager: V. Elaguppillai

   In Progress:

   Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure (7.119.2)

   Planned:

   Childhood Leukemia around Canadian Nuclear Facilities (2.162.1)

3. INHALATION STUDIES

   Project Manager: P.J. Duport

   In Progress:

   Study of the Health Effects of Inhaled Uranium Ore Dust (4.101.1)

4. DOSIMETRIC MODELS

   Project Manager: P.J. Duport

   In Progress:

   Evaluation of Data and Models on Uranium Metabolism (3.111.1)

5. LUNG SOLUBILITY STUDIES

   Project Manager: K.P. Ho

   In Progress:

   Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities (4.103.2)

Project Manager: P.J. Duport

Planned:

Influence of Macrophages on Dissolution of Uranium Compounds (3.123.1)

6. RELATIVE BIOLOGICAL EFFECTIVENESS (RBE)

Project Manager: E. Rabin

In Progress:

Measurement of RBE for Tritium for Myeloid Leukemia (2.154.2)

7. BRONCHIAL EPITHELIUM

Project Manager: E. Rabin

In Progress:

Measurement of the Thickness of Bronchial Epithelium (4.121.1)

8. RADIOSENSITIVITY OF BIOLOGICAL SYSTEMS

Project Manager: E. Rabin

In Progress:

Screening of Human Populations for Abnormal Radiosensitivity (7.110.1)

9. URANIUM TOXICITY

Project Manager: E. Rabin

Planned:

Study of the Effect of Uranium on Kidney Function (3.122.1)

10. HYDROGEOLOGY

Project Manager: J.L. Wallach

Planned:

Coupled Processes in the Assessment of Deep Disposal (5.118.1)

Uncertainty in the Interpretation of Hydrogeologic Data (5.119.1)

11. ENVIRONMENTAL PATHWAYS

Project Manager: R. Avadhanula

Planned:

Transfer of Radionuclides to Human Milk - Phase 3 Field Study (3.106.3)

Radiation Sensitivity of Organisms Other than Man: A Review (3.116.1)

Calibration/Validation of FEMWATER/FEMWASTE on the Nordic Site (5.121.1)

12. SOFTWARE RELIABILITY

Project Manager: D.E. Connelly

Planned:

Documentation of Real-Time Power Reactor Software (2.117.1)

Estimating Software Reliability for Reactor Shutdown Systems (2.134.1)

Software Quality Assurance for Waste Disposal Models (5.115.1)

13. GEOCHEMISTRY

Project Manager: J.L. Wallach

Planned:

An Evaluation of Contaminant Retardation Mechanisms (5.124.1)

14. SEVERE ACCIDENTS

Project Manager: A. Omar

Planned:

Consequences of Severe Accidents in Canadian Power Reactors (2.157.1)

## List of corresponding old and new ID numbers, as of Tue, Feb 16, 1988

| Old ID | New ID | Project title |
|---|---|---|
| 84.1.06 | 2.101.1 | Instrument Behaviour under Off-Normal Conditions |
| 84.1.20 | 2.102.1 | A Tool to Analyze Real-Time Programs |
| 84.8.10 | 7.101.1 | The Canadian National Dose Registry Study |
| 84.8.11 | 4.101.1 | Study of the Health Effects of Inhaled Uranium Ore Dust |
| 84.8.14 | 4.121.1 | Measurement of the Thickness of Bronchial Epithelium |
| 84.8.15 | 2.154.2 | Measurement of RBE for Tritium for Myeloid Leukemia |
| 85.1.08 | 2.105.1 | Crack Propagation in Tough Ductile Materials |
| 85.3.06 | 4.103.2 | Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities |
| 85.3.10 | 4.104.1 | Radon/Thoron Fluxes in Uranium Mines (Ontario) |
| 85.8.07 | 7.105.1 | Epidemiological Study of Radiation-Induced Developmental Defects |
| 85.8.08 | 4.102.1 | Review of Techniques Used to Assess Past Exposures to Radon |
| 85.8.12 | 3.103.1 | Absorbed Fraction of Ingested Uranium in Humans |
| 85.8.13 | 7.106.2 | Effects on Central Nervous System from In Utero Exposure |
| 85.8.18 | 7.109.1 | Epidemiological Study of Genetic Disorders in Adults |
| 85.8.20 | 7.110.1 | Screening of Human Populations for Abnormal Radiosensitivity |
| 85.8.22 | 7.111.1 | In Vitro and In Vivo Studies of the Effects of Ionizing Radiation on the Developing Central Nervous System |
| 86.1.03 | 2.108.1 | Survey of NPP Environments for Equipment Qualification |
| 86.1.18 | 2.111.1 | International Piping Integrity Research Group |
| 86.1.21 | 2.114.2 | A Simulator for Evaluating Emergency Operating Procedures |
| 86.1.24 | 2.114.1 | Acquisition of a Simulation Shell Program and Documentation |
| 86.3.01 | 4.108.1 | Intercomparison of Dust Sampling Instruments |
| 86.3.02 | 4.109.1 | Measurement of the Unattached Fraction with Wire Screens |

## List of corresponding old and new ID numbers, as of Tue, Feb 16, 1988

| Old ID | New ID | Project title |
|---|---|---|
| 86.3.5 | 4.110.1 | Modified Personal Alpha Dosimeter for Uranium Mines |
| 86.4.02 | 3.104.1 | Neotectonic Conditions in Eastern Canada - Phase I |
| 86.6.04 | 6.102.1 | Radiation Doses to Technologists from Radiotherapy |
| 86.7.01 | 8.101.1 | Doses to Road Transport Workers from Radioactive Materials |
| 86.8.08 | 7.116.1 | Cancer Morbidity Follow-Up Feasibility Study |
| 86.8.11 | 7.117.1 | Hospital Record-Keeping System for Epidemiological Studies |
| 86.8.12 | 7.118.1 | Selection of Control Groups for Epidemiological Studies |
| 86.8.15 | 7.119.2 | Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure |
| 86.8.18 | 4.106.2 | Ontario Miners Mortality Study - Update |
| 86.9.03 | 9.102.1 | Review of Crisis Management Methods |
| 87.1.03 | 2.117.1 | Documentation of Real-Time Power Reactor Software |
| 87.1.04 | 2.118.1 | Behaviour of the Calandria Structure under Severe Conditions |
| 87.1.05 | 2.119.2 | Updating of the DARSIM Simulation Program |
| 87.1.06 | 2.120.1 | Models for Molten Fuel/Moderator Interaction |
| 87.1.08 | 2.122.1 | Non-Uniformity of Hydrogen in Fuelling Machine Vaults |
| 87.1.09 | 2.123.1 | Effect of Geometry on Hydrogen Burn in Calandria |
| 87.3.01 | 4.112.1 | Electrical Charge of Radioactive Aerosols in Uranium Mines |
| 87.3.2 | 4.113.1 | Tracer Gas Method for Assessing Ventilation Efficiency |
| 87.4.01 | 3.107.1 | Stresses to Induce Failure across Faults and Fractures |
| 87.4.03 | 5.110.2 | Measurement of Thorium Concentration in Fish: A Field Study |
| 87.4.06 | 5.111.1 | Effective Communication with the General Public |
| 87.4.07 | 3.106.3 | Transfer of Radionuclides to Human Milk - Phase 3 Field Study |

## List of corresponding old and new ID numbers, as of Tue, Feb 16, 1988

| Old ID | New ID | Project title |
|---|---|---|
| 87.5.04 | 5.115.1 | Software Quality Assurance for Waste Disposal Models |
| 87.6.01 | 6.103.1 | Beta-Gamma Counting of Ra-228/Ac-228 in Urinalysis |
| 87.6.02 | 6.104.1 | Production of a Hospital Radiation Safety Officer's Handbook |
| 87.8.01 | 3.111.1 | Evaluation of Data and Models on Uranium Metabolism |
| 87.8.04 | 2.125.1 | Carbon-14 in Food and in Excretions |
| 87.8.05 | 7.121.1 | Cancer Mortality among Cardiac Catheterization Patients |
| 87.8.06 | 7.122.1 | Computerized Linkage of National Cancer Incidence Data |
| 87.8.08 | 3.115.1 | Neutron Dosimeters and Survey Meters in Accelerators (I) |
| 87.8.12 | 7.126.1 | Use of An Employee Identification Questionnaire and Guide |
| 87.8.13 | 7.127.1 | Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens |
| 87.8.14 | 3.115.2 | Neutron Dosimeters and Survey Meters in Accelerators (II) |
| 87.8.15 | 7.128.1 | The Relative Impact of Radiation-Induced Genetic Disorders |
| 87.8.16 | 3.116.1 | Radiation Sensitivity of Organisms Other than Man: A Review |
| 87.9.02 | 9.103.1 | Study of the AECB Long Range Plan for Information Management |
| 87.9.03 | 9.104.1 | Regulatory Effectiveness Measurement System |

| STANDARD ABBREVIATIONS AECB ORGANIZATIONAL UNITS | | SIGLES COURANTS DES UNITÉS ORGANISATIONNELLES DE LA CCEA |
|---|---|---|
| Office of the President | OPR | Bureau du Président |
| Advisory Committee on Radiation Protection | ACRP | Comité consultatif de la radioprotection |
| Advisory Committee on Nuclear Safety | ACNS | Comité consultatif de la sûreté nucléaire |
| Secretariat | SEC | Secrétariat |
| Secretary to the Board | SEB | Secrétaire de la Commission |
| Office of Public Information | OPI | Bureau d'information publique |
| Advisory Committee Secretariat | ACS | Secrétariat des groupes consultatifs |
| Legal Services Unit | LSU | Services juridiques |
| Official Languages Advisor | OLO | Conseiller en langues officielles |
| Medical Liaison Officer | MLO | Agent de liaison médical |
| Director of Reactor Regulation | DRR | Direction générale, Réglementation des réacteurs |
| Safety Evaluation Division | SED | Division, Évaluation de la sûreté |
| Components and Quality Assurance Division | CQAD | Division, Composants et assurance-qualité |
| Power Reactor Division A | PRDA | Division A, Réacteurs de puissance |
| Power Reactor Division B | PRDB | Division B, Réacteurs de puissance |
| Operator Certification and Research Facility Division | OCRFD | Division, Accréditation des opérateurs et établissements de recherche |

| | | |
|---|---|---|
| Directorate of Fuel Cycle and Materials Regulation | DFC | Direction générale, Réglementation des matières nucleaires et des radioéléments |
| Office of Safeguards and Physical Security | OSS | Bureau des garanties et de la sécurité matérielle |
| Safeguards and Security Division | SSD | Division, Garanties et sécurité |
| Radioisotopes and Transportation Division | RTD | Division, Radio-isotope et transports |
| Compliance Services and Laboratories Division | CSLD | Division, Contrôles et laboratoires |
| Uranium Mine Division | UMD | Division, Mines d'uranium |
| Waste Management Division | WMD | Division, Gestion des déchets |
| Fuel and Heavy Water Plant Division | FWD | Division, Usines de combustibles et d'eau lourde |
| Planning and Administration Branch | PAB | Direction, Planification et administration |
| Planning and Coordination Section | PCS | Section, Planification et coordination |
| Administration Division | ADD | Division, Administration |
| Finance Section | FIS | Section, Finances |
| Personnel Section | PES | Section, Personnel |
| Information Management Section | IMS | Section, Traitement de l'information |
| Research and Radiation Protection Branch | RRB | Direction de la recherche et de la radioprotection |
| Radiation Protection Division | RPD | Division, Radioprotection |
| Health and Environmental Effects Section | HES | Section des effets sur la santé et l'environnement |

| | | | |
|---|---|---|---|
| Safety and Safeguards Section | | SSS | Section, Sûreté et garanties |
| Editorial Support Services (OPI) | | SAR | Service d'appui à la rédaction |
| Project Office | - Bruce | POB | Bureau de projet - Bruce |
| | - Darlington | POD | - Darlington |
| | - Gentilly | POG | - Gentilly |
| | - Point Lepreau | POL | - Point Lepreau |
| | - Pickering | POP | - Pickering |
| Laboratory | | LAB | Laboratoire |
| Regional Offices: | | | Bureaux régionaux: |
| Central Region | | CRO | Région central |
| Eastern Region | | ERO | Région de l'Est |
| Southern Ontario Region | | SORO | Région du Sud de l'Ontario |
| Western Ontario Region | | WRO | Région de l'Ouest |
| Elliot Lake | | ELO | Elliot Lake |
| Accommodation and Material Management | | AMM | Gestion des locaux et du matérial |
| Records Office | | REC | Bureau des documents |
| Library | | LIB | Bibliothèque |
| Administrative Support Group (Floor) | | AS4<br>AS5<br>AS6<br>AS7<br>AS8 | Groupe de soutien administratif (Étage) |

# PROJECT SUMMARIES

## 2.101.1 Instrument Behaviour under Off-Normal Conditions

It is proposed to conduct a study on the behaviour, during and after selected hypothetical severe accident conditions, of instruments used in CANDU reactors. Emphasis would be placed on the accuracy of thermocouples, pressure transducers and flow meters during and after being forced to operate at the extremes of, or outside, their scales.

Information on instrument behaviour during and after severe accident conditions is scarce. This work, therefore, would generate new knowledge necessary to improve the understanding of instrument readings during and after abnormal events.

The results of this study would be used in assessing licensee assumptions and interpolations regarding accident scenarios described by instrument-reading records.

| | |
|---|---|
| Proponent | SSS, SED |
| Evaluator | SED (B. Finigan) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $0K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 2.102.1 A Tool to Analyze Real-Time Programs

A project is proposed to survey the latest developments in computer program analysis and testing, using graph theory as applied to real-time critical systems. Then, based on the results of the survey, it is proposed to acquire or develop a program graphing software tool to analyze the complexity and verification/validation test coverage aspects of safety-related nuclear system software.

Due to the combination of the number of inputs and processing pathways, computer programs used to control nuclear reactor systems are very difficult to verify and validate to an acceptable degree of confidence. Even using extensive test data some design and programming faults may go undetected resulting in the possibility of a critical failure at some future time given a certain set of input and processing conditions.

The results of the survey phase would provide AECB staff with the latest information concerning analysis of critical software, enabling a knowledgeable assessment of the particular methods and test data used by licensees to verify and validate their nuclear software. The resulting software tool may provide an effective means for AECB staff to rigourously and independently evaluate the testability of a particular system and the extent of test coverage proposed by the licensee.

| | |
|---|---|
| Proponent | SED, SSS |
| Evaluator | SED (J. Kendall) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $60K | $0K | $0K | $60K |

Earlier Directly-Related Contracts and Funding:

## 2.105.1 Crack Propagation in Tough Ductile Materials

It is proposed: a) To perform experimental work which would examine elastic-plastic fracture behaviour in steels which are typical of materials used in CANDU primary heat transport systems; and to explore whether small specimen tests can be used to characterize "lower bound" crack behaviour under the range of elastic-plastic strain conditions encountered in CANDU primary heat transport system components (Phase 1). b) To evaluate the effectiveness of crack displacement and energy based fracture toughness methods of describing crack propagation behaviour under elastic-plastic strain conditions. This should include studies of the individual approaches and an investigation into the viability of a combined energy and crack displacement approach as a route towards a representative model for a wide range of crack growth (Phase 2).

The project arises from the recommendations of a recently completed review of crack and fracture behaviour in tough, ductile materials (84.1.38), which showed a need to incorporate elastic-plastic fracture mechanics considerations into the analysis and design of metallic structural components. The project is aimed at the eventual development of a practical method for the analysis and assessment of stable crack growth under elastic-plastic strain conditions.

The results of the project would be used as reference information to enable more effective appraisal of safety margins in defect dispositioning and other crack stability assessment work.

| | |
|---|---|
| Proponent | CQAD |
| Evaluator | CQAD (J.K. Pereira) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | University of Toronto |
| Principal Investigator | |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $45K | $15K | $30K | $0K | $0K | $90K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 84.1.38 | $25000 | $0 | $0 | | $25000 |

## 2.108.1 Survey of NPP Environments for Equipment Qualification

It is proposed: a) to determine the expected type and range of actual plant environments (in selected plants and plant areas) to which various safety-related equipment and components are normally exposed during their service life; and b) to assess if the currently used accelerated aging methods account for these environments. The contractor would obtain available data on measured plant environments (e.g. radiation, thermal, mechanical stress, gas) and, as necessary, would measure actual environments during plant operation in selected plants and plant areas, and would assess the type and range of the environments and their simulation by the currently used accelerated aging methods.

To assure a conservative basis for equipment qualification testing, equipment should be tested in a state equivalent to the end-of-qualified life condition. Since it is not practical to naturally age equipment to the end-of-life condition, accelerated aging techniques are used to change the equipment to be tested to a state equivalent to end-of-life. To be able to simulate natural aging, actual plant environments must be known.

The project results would enable AECB staff to assess whether the accelerated aging methods reported in EQ licensing submissions adequately account for normal NPP environments.

| | |
|---|---|
| Proponent | SSS, PRDA&B |
| Evaluator | PRDA |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

## 2.110.2 Plant Air Quality Following Accidental Releases, Phase 2

It is proposed to continue on previous experimental work to understand the phenomenon of near-field atmospheric dispersion within and around the buildings of a nuclear facility under various release and weather conditions.

Previous preliminary study on plant air quality following accidental radioactive releases clearly demonstrates the potential of ingress of very high concentrations of contaminated air from roof discharges into the air intakes of the same building or surrounding buildings. It confirms that there are no adequate mathematical models to predict flow and estimate concentrations around buildings, especially around building complexes. In particular empircal formulas fail dramataically as the wind speed approaches zero as these formulas predict infinite concentrations.

The results of this project would be used to further our understanding of plant air quality and habitability of the plants following severe accidents.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (L. Truong) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | Envirodyne Ltd. |
| Principal Investigator | P. Slawson |
| Category | 2 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $40K | $0K | $0K | $40K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.110.1 | $22000 | $8000 | $0 | | | $30000 |

## 2.111.1 International Piping Integrity Research Group

It is proposed to continue membership in the International Piping Integrity Research Group (IPIRG). This group, organized by the U.S. Nuclear Regulatory Commission (USNRC), is examining the fracture behaviour of large piping systems. The proposed program by the USNRC includes: fracture tests done on approximately 60 large-diameter pipes, of which about one third are directly relevant to CANDU; material tests to establish a data base for fracture analysis; assessment of the efficacy of fracture calculations; review of degraded piping; and review of the state-of-the-art analytical and experimental developments. The cost of Canadian participation in the IPIRG program would be shared equally between AECB and Ontario Hydro (each contributing $420K).

There is a need to develop and verify the technology to justify: using analytical assessments to disposition piping defects and prescribe inspection frequencies for them; permitting leak-before-break concepts in lieu of mechanical protection for hypothetical pipe ruptures; and current procedures for response to primary heat transport system leaks.

The results would be used to support, or change, the licensing criteria for protection against pipe rupture, to define in-service inspection frequencies, and to develop rules for reactor shutdown after leaks have been detected.

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|---|---|
| Proponent | CQAD |
| Evaluator | CQAD (B. Jarman) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | USNRC/Battelle |
| Principal Investigator | M Mayfield |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $132K | $140K | $140K | $0K | $412K |

Earlier Directly-Related Contracts and Funding:

## 2.114.1 Acquisition of a Simulation Shell Program and Documentation

It is proposed to purchase from AECL a computer program called SIMAK and have prepared complete documentation. The program allows interactive simulation to be run on an IBM PC when modules of specific models are "plugged in" to the SIMAK shell.

Safety Evaluation Division has expressed the need for a tool to evaluate emergency operating procedures at CANDU plants. The most effective tool would be an interactive computer simulation program. As a first step in obtaining this tool, the simulation language (or "shell") SIMAK is to be purchased and complete documentation is to be prepared. Subsequently, a contract will be funded to have the specific modules of a CANDU 600 MW reactor written and installed in SIMAK.

The purchased program will be used in preparing an analysis tool: an interactive computer simulation of a CANDU 600 MW reactor.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (J. Kendall) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

## 2.114.2 A Simulator for Evaluating Emergency Operating Procedures

A research project is proposed which would produce a series of computer modules which simulate the general features of a CANDU 600 MW reactor. The modules would "plug in" to an existing simulation environment (SIMAK).

This project is prompted by a review of Emergency Operating Procedures (EOP) that indicated the need for an analytical tool to assist in understanding the interaction of various plant systems. For example, during a small LOCA from the steam space above the pressurizer at low power, one would expect the pressure to drop quickly and the pressurizer level to drop by about 10% and then rise rapidly. At full power, the pressurizer level should rise as the pressure drops. Such an hypothesis could be tested with this simulation.

The simulation will be used to develop an understanding of the way in which a CANDU 600 MW reactor responds to various accident conditions. This understanding is required to evaluate the suitability of the form and diagnostics in an EOP.

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|---|---|
| Proponent | SED |
| Evaluator | SED (J.D. Kendall) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $40K | $0K | $0K | $40K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 86.1.24 | $12000 | $0 | $0 | | | $12000 |

## 2.117.1 Documentation of Real-Time Power Reactor Software

It is proposed to survey software documentation standards and practices applicable to real-time systems and identify documentation techniques and elements that would be effective over the entire life cycle of CANDU computer-based process control and safety systems. This project would be initiated following completion of 2.127.2 to derive full benefit from, and to consolidate the particular experience of, 2.127.1 and 2.127.2.

Real-time software is being applied extensively both in the newer CANDU power stations and for retrofitting older stations. In addition, existing operational software must undergo many changes throughout its operational phase to correct faults and to adapt to additional requirements. To further complicate the situation, the electrical utilities will likely be left responsible for software system support as their system suppliers and consultants are forced by economic pressures to reduce their activities in this area.

The results of this study would assist AECB staff in assessing the adequacy of documentation for real-time software systems in use and proposed in CANDU nuclear power stations.

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|---|---|
| Proponent | SED |
| Evaluator | SED (J. Kendall) |
| Project Manager | D.E. Connelly |
| Panel | 12 |
| Contractor | |
| Principal Investigator | |
| Category | 2 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

## 2.118.1 Behaviour of the Calandria Structure under Severe Conditions

It is proposed to conduct an analytical study to investigate the survivability of the calandria structure under a hypothetical rapid increase in the temperature and pressure of the moderator.

It is uncertain how the calandria structure would eventually fail when subjected to a rapid increase in the temperature and pressure of the moderator. If the upper portion of the calandria (i.e. the reactivity mechanism deck) were to fail first, this would result, on certain CANDU designs, in a breach of containment. Information is needed, therefore, to determine the consequences of such a hypothetical situation, and then, if necessary, the measures which would be considered to prevent it or mitigate its consequences.

The results of this project would expand the knowledge-base of AECB staff and augment their understanding of the behaviour of a CANDU reactor under a combination of hypothetical human errors and systems response.

| | |
|---|---|
| Proponent | SED, PRD |
| Evaluator | CQAD (B. Jarman) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $60K | $30K | $0K | $90K |

Earlier Directly-Related Contracts and Funding:

## 2.119.2 Updating of the DARSIM Simulation Program

A project is proposed which would update the DARSIM simulation program to incorporate the expected changes to the Darlington reactor digital shutdown system.

While constructing the Darlington reactor simulation program DARSIM for the AECB, the contractor (Serdula Systems) discovered several important discrepancies between the specification document for the shutdown system and the implementation description document. This means that, as the system stands at present, the trip coverage may not be complete. Some amendments to the specifications of the shutdown system have been made. However, when the licensee completes the changes required to the system, DARSIM will have to be updated to reflect these changes.

The updated DARSIM program would be used in the continuing review of the safety of the proposed Darlington reactor.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (J. Kendall) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | Serdula Systems |
| Principal Investigator | K. Serdula |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $30K | $12K | $0K | $0K | $42K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 85.1.10 | $29000 | $0 | $0 | | $29000 |

## 2.120.1 Models for Molten Fuel/Moderator Interaction

It is proposed to conduct an analytical study to estimate the thermalhydraulic loadings due to steam explosion using different sets of assumptions reflecting various degrees of conservatism. The study would include: a) an upper bound analysis of transient pressure fields resultings from a steam explosion; and b) an investigation to determine the most influential parameters that might lead to a steam explosion. This would be a follow-up to a previous study (84.1.30) in which existing models were critiqued and the potential for steam explosion in a CANDU system assessed.

The predicted severity and consequences of the interaction between molten fuel and moderator depend on the model adopted. Models are normally based on numerous assumed factors. By carrying out a comparison between models, and then conducting an upper bound analysis, it is anticipated that the consequences of a hypothetical block fuel channel event can be addressed.

The results of this project would be used by AECB staff in evaluating the models used for, and the consequences of, a hypothetical case in which a pressure tube/calandria tube rupture takes place with molten fuel interacting with the moderator.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (V. Tang), CQAD (B. Jarman) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | Swacer Inc. |
| Principal Investigator | J.H.S. Lee |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $36K | $16K | $0K | $0K | $52K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 84.1.30 | $49000 | $0 | $0 | | $49000 |
| 2.095.2 | $4591 | $1789 | $0 | | $6380 |

## 2.122.1 Non-Uniformity of Hydrogen in Fuelling Machine Vaults

It is proposed to determine the extent of the non-uniformity of hydrogen concentration in a fuelling machine vault following a LOCA and LOCA with LOECC. The work would involve flow visualization and measurement of spatial distribution of hydrogen concentration as a function of time in a 1:10 to 1:20 scale model of the Pickering fuelling machine vault used as a typical case. The location of the hydrogen source, the rate of hydrogen discharge and the hydrogen/steam ratio are the parameters which would be studied.

Current research on hydrogen burn in the fuelling machine vault is aimed at developing a technical basis for predicting the consequences of the burn in terms of pressure and temperature rise in the vault. Important characteristics such as flammability limits, flame propagation and transition to detonation are being investigated, however, burning in non-uniform mixtures has not been addressed. Since hydrogen burning and hence its consequences could be strongly dependent on the hydrogen concentration non-uniformities, it is necessary to determine whether significant non-uniformities could exist in the fuelling machine vault following a LOCA and LOCA with LOECC despite the mixing of gases by the vault cooling fans.

Results of this research would determine whether hydrogen burning in non-uniform mixtures should be investigated in order to predict realistic consequences of hydrogen burn in the fuelling machine vault.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (J. Khosla) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $0K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 2.123.1 Effect of Geometry on Hydrogen Burn in Calandria

It is proposed to investigate the burning characteristics of hydrogen in the calandria under conditions of low moderator level. The work would involve measurements of hydrogen burning rate and flame velocities in the axial and lateral directions using representative mixtures of hydrogen, helium, steam and oxygen in a full to 1:10 scale model of the upper segment of the calandria vessel which would include both the calandria and reactivity mechanism tubes.

Current hydrogen combustion research includes studies related to hydrogen burn in the calandria which could occur following postulated events involving drop of moderator level below the top row of calandria tubes. Deuterium evolution, flammability and detonation limits, ignition and other characteristics are being investigated, however, hydrogen burning in actual calandria geometry is not being addressed and this is a factor which is likely to significantly influence hydrogen burning rate and propagation, and consequently the event sequences.

The results of the research would enable the AECB staff to assess whether the consequences of hydrogen burn predicted on the basis of tests in simple geometries are representative of those likely to occur in the calandria.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (J. Khosla) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $0K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 2.125.1 Carbon-14 in Food and in Excretions

It is proposed to measure the amount of carbon and the specific activity of radioactive carbon (C-14) in the daily intake of food and in the daily excretions of urine and stool obtained from healthy persons.

At present, the daily excretion rate of C-14 due to occupational exposure to radioactive carbon dioxide and to particulates containing C-14 is calculated by measuirng the specific activity (C-14 per gram of stable carbon) in an aliquot of urine or stool, and by adjusting for the total stable carbon output in a 24-hour excretory sample. The amount of stable carbon excreted in a daily sample cannot usually be measured, and it is assumed to be equal to that given for Reference Man in ICRP 23. Additionally, an accurate dose estimation due to an uptake of C-14 requires a knowledge of the relative fraction of ingested C-14, which is eventually excreted in both urine and stool samples. There appears to be significant uncertainty in the values for Reference Man given in ICRP 23. It is therefore important to measure these parameters to enable an accurate dose estimation for exposure to C-14 in occupational situations.

The results of this study will improve dose estimates for exposure to C-14 among workers at nuclear facilities and among radioisotope users where C-14 is present.

| | |
|---|---|
| Proponent | RPD |
| Evaluator | RPD (F. Horvath) |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $20K | $0K | $70K |

Earlier Directly-Related Contracts and Funding:

## 2.127.3 Evaluation of Computerized Shutdown System (III)

It is proposed to evaluate the safety and reliability aspects of the software used in the trip computers of the Safety Shutdown Systems for the Darlington Nuclear Generating Station. The previous two phases reviewed the software structural level for both shutdown systems. Phase 3 would consist of the following activities for the trip computer software of Shutdown System 1: a) determine the most effective methods to evaluate in detail the system's logical level from the viewpoint of safety, based on the documentation available and the system's characteristics; and b) use these methods to carry out the safety evaluation.

All of the Darlington Shutdown System functions have been implemented in software hence the safety of the station is highly dependent on the safe execution of this software. Due to the large number of inputs and processing pathways it is not sufficient to rely solely on verification and validation testing to assure fault detection to an acceptable degree of confidence. Analysis of the safety aspects of the software is essential to detect complex and subtle design and implementation errors and to determine if the licensee's testing effort resources have been focussed on the critical areas.

The results of this study will be used by AECB staff in assessing the software integrity of the Darlington shutdown systems.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (J. Kendall) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 2 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $75K | $0K | $0K | $75K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 2.127.1 | $0 | $31000 | $0 | | $31000 |
| 2.127.2 | $0 | $57000 | $0 | | $57000 |

## 2.128.2 Review of BNPD Fire-Fighting Capability Assessment Program

A contract is proposed which would evaluate the Bruce Nuclear Power Development fire-fighting capability assessment program, using information obtained in the preliminary assessment (contract 2.128.1).

AECB staff is concerned that the capability of Ontario Hydro Bruce Nuclear Power Development (BNPD) site fire crews to cope with a major fire has not been fully assessed or exercised. In response to this concern, Ontario Hydro has made the commitment to determine the adequacy of the fire fighting capability at the individual stations of the BNPD site. The AECB requires an expert review of the assessment program.

The results of this contract will be used by AECB staff to determine whether the utility has demonstrated adequate capability to cope with major fires at the BPND.

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|---|---|
| Proponent | SED |
| Evaluator | SED (B. Finigan) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $6K | $0K | $0K | $6K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 2.128.1 | $0 | $3000 | $0 | | $3000 |

## 2.130.1 Self-Testing of Programmable Controllers & Microcomputers

It is proposed to initiate a two phase project to develop guidelines for the review of self-test systems in custom engineered programmable controllers (PCs) and industrial microcomputers (IMs) used in safety related and special safety control systems for CANDU nuclear power stations. Phase I would review the current and proposed equipment and similar off-the-shelf manufactured products, along with the particular electronic technologies applied to identify the possible hardware failure modes and to develop a description of the hardware faults to be detected by an adequate self-test system. Phase II would describe, in detail, methods to detect the hardware faults identified in Phase I, would develop a comprehensive checklist and set of guidelines for self-test dependent on particular electronic technologies, and would, as illustrative examples, evaluate the systems from Phase I using these guidelines.

The use of PCs and IMs is extensive in CANDU nuclear power stations both in new stations and for the retrofitting of older units. This technology involves a complex blend of real-time software and high performance microcircuit devices for which the realability history is limited. Guidelines are required to allow AECB staff to evaluate the adequacy of the self-test systems with respect to fault-detection and the contribution to overall reliability.

The results of this project would assist AECB staff in the assessment of the self-test methods used in the shutdown systems at Darlington Nuclear Generating Station and in the OH-180 Programmable Controllers used throughout Darlington's safety related control systems.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (B. Finigan, J. Kendall), PRD-B (I. Lee) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $70K | $0K | $0K | $70K |

Earlier Directly-Related Contracts and Funding:

## 2.131.1 Review of 12-Hour Shifts at Nuclear Generating Stations

It is proposed to fund a project to review the literature for the latest information on the use of 12-hour shifts as applicable to the nuclear industry. The contractor would also a) review the study reports and other relevant correspondence that led to the AECB decision to confirm the use of 12-hour shifts for Ontario Hydro nuclear generating stations; b) indicate, if they exist, any significant factors that have not been considered adequately, and that have a direct bearing on the issue; c) recommend, if required, any additional studies, research or other actions that the AECB or the licensee should undertake; and d) recommend guidelines for the evaluation of a 12-hour shift overtime policy.

The AECB accepted in 1986 a recommendation by Ontario Hydro that 12-hour shifts be approved for nuclear generating stations. As part of the AECB's on-going reviews of safety, an independent view is required of the use of 12-hour shifts.

The results of the project will be used as one input to the AECB's on-going review of the relationship between safety and 12-hour shifts.

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| Proponent | SED |
| Evaluator | SED (J. Kendall) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $20K | $15K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

## 2.132.1 Review of Software Configuration Management at Darlington

It is proposed to review the Software Configuration Management systems to be used to control the software for the reactor control computers, safety shutdown systems and the programmable controllers used at Darlington Nuclear Generating Station.

Darlington will make extensive use of real-time software in numerous mini and microcomputers at different revision levels and in many different configurations. For example, the OH-180 programmable controllers have a hierarchy of four levels of interacting software with the lower level consisting of approximately 500 different application programs. In such a situation, careful management of software changes is essential to safety.

The results of this project will be used by AECB staff in evaluating the safety aspects of the application of computers to special safety systems and safety related systems.

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| Proponent | SED |
| Evaluator | SED (J. Kendall) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $30K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.109.1 | $10000 | $10000 | $0 | | | $20000 |

## 2.133.1 Review of the SLOWPOKE Demonstration Reactor Control System

It is proposed to review that control system for the SLOWPOKE Demonstration Reactor (SDR) to determine whether the proposed control system configuration is appropriate for safe operation.

The dynamics of the SDR are characterized by a number of very long time constraints, time delays and non-linearities. Therefore the design criteria and techniques commonly used for conventional nuclear reactor control systems may not be applicable.

This work will assist AECB staff in evaluating the effectiveness of the SDR control and safety systems over a full range of normal and abnormal operating conditions.

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| Proponent | SED |
| Evaluator | SED (B. Finigan, J. Kendall) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $35K | $0K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

## 2.134.1 Estimating Software Reliability for Reactor Shutdown Systems

It is proposed to initiate a multi-phased project that would address the question of estimating the contribution of the software to the unavailability to trip for the Darlington trip computer systems. The project would be carried out in the following phases: 1) determine whether it would be technically feasible to estimate the software's unavailability contribution to an acceptable degree of confidence for the trip computer systems; 2) if feasible, estimate the unavailability contribution for the Shutdown System 1 trip computer software; and 3) repeat phase 2 for Shutdown System 2. This project would be carried out in association with project 2.127.3.

The current unavailability analyses for the Darlington Shutdown Systems do not include the software contributions. Experience with similar critical software systems in aerospace and telecommunication applications indicates that the software contributions to system unavailability could be significant.

The results of this study would assist AECB staff in evaluating the Probability Safety Analyses for the Darlington Shutdown Systems.

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| Proponent | SED |
| Evaluator | SED (B. Finigan, T. Leung, J. Kendall) |
| Project Manager | D.E. Connelly |
| Panel | 12 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $75K | $75K | $50K | $200K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 2.127.1 | $0 | $31000 | $0 | | $31000 |
| 2.127.2 | $0 | $57000 | $0 | | $57000 |

## 2.135.1 In-Service Degradation of NPD Heat Transport Piping

It is proposed to determine the extent of degradation present in the NPD reactor primary heat transport system piping after 25 years in service. The work would involve selection of appropriate piping samples, collection of relevant design, operational and maintenance data, inspection, removal and laboratory tests to assess possible damage caused by erosion, corrosion and other degradation mechanisms. Measured material strength and fracture toughness parameters, which characterize load-bearing capability of carbon steel in pipes and welds, would be compared with ASME code data and baseline data, if available. This would be a joint project with Ontario Hydro with a total cost of approximately $90K.

Materials used for the NPD primary heat transport piping system comprise mainly ferritic steels which were selected from a range of standard steel materials. In other words, they have not been specially qualified or developed for a nuclear service type duty. The proposed evaluation of their behaviour/degradation after 25 years of nuclear service would provide useful information related to the development of life expenditure models, their current fitness for service, and the merit of the material selection criteria used.

Results of the proposed work would in general contribute to the current understanding of degradation of carbon steel piping and welds in long-term nuclear service, and especially would improve the AECB capability to assess expected licensees' submissions related to the use of high grade commercial piping in nuclear service.

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| Proponent | CQAD |
| Evaluator | CQAD (J.K. Pereira) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $17K | $0K | $0K | $17K |

Earlier Directly-Related Contracts and Funding:

## 2.136.1 Commercial Pressure Retaining Components in Nuclear Service

It is proposed to review practices for qualification and acceptance of high grade commercial components for pressure-retaining system service. The focus is to be directed at components which are not designed for specific applications but which are available for selection from standard product lines.

The reduction, in recent years, in the number of nuclear power projects being actively pursued has led to the withdrawal, from the market, of many manufacturers and suppliers of 'nuclear grade' components. The utilities have thus been driven to seek alternative sources for certain categories of components. One option being explored for certain applications is to utilize high grade commercial components which come from standard product ranges with a proven record of quality and reliability. This project seeks to examine component qualification practices used for such components, for comparison with requirements for nuclear system service.

The results of the review would give technical background information for use in assessing the merits of proposals to use high grade commercial components in nuclear pressure retaining service applications.

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| Proponent | CQAD |
| Evaluator | CQAD (J.K. Pereira) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 2.137.1 Hydrogen Combustion in Calandria

It is proposed to assess the validity of the assumptions made in the safety analysis, and of the predicted consequences, of a hydrogen burn inside the calandria. The work would include assessments of the type of hydrogen burn, the flame velocity (and its dependence on the presence of calandria internals), and the effect of venting. In addition, a review of the industry research program would be conducted to determine whether additional research work is required.

The concentration of hydrogen in the cover gas space in the calandria may increase following a loss of moderator level control or a break in the moderator system. The fall in the moderator level may also result in increasing the temperature of some of the reactivity mechanism devices (in particular cobalt adjusters) and thus form a heat source for the ignition of hydrogen. The predicted consequences of a hydrogen burn inside the calandria, including the peak pressure, are sensitive to the assumptions made. An expert assessment of the licensee's analysis, including the validity of the assumptions made, is needed as an input to the AECB licensing process.

This assessment would help the AECB in making regulatory decisions related to the predicted consequences of a loss of moderator inventory accident. In addition, the assessment of the adequacy of the industry's research program would provide the technical basis for possible improvements to the program.

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| Proponent | SED |
| Evaluator | SED (J.K. Khosla) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 2.138.1 Hydrogen Combustion in Containment

It is proposed to assess the validity of licensee safety analyses of a hydrogen burn inside the containment following LOCA and LOECC. The work would include assessments of validity of the assumptions made in the analysis, predicted consequences and their sensitivity to the assumptions made. In addition, a review of the adequacy of the industry research program in support of this licensing issue would be conducted.

A number of simplifying assumptions have been made in the safety analysis with respect to hydrogen burn. For example: uniform hydrogen concentration in the reactor vault, hydrogen burn velocity, effect of the presence of various equipment and structures in the vault, etc. Since the calculated peak pressure in the vault can be very sensitive to some of these assumptions, an expert opinion is sought to assess the validity of the safety analysis in light of current knowledge.

Results of the proposed work would help the AECB in making regulatory decisions related to the adequacy of the analysis of, and the provisions for dealing with, hydrogen burn inside the containment following LOCA and LOECC. Furthermore, improvements of the pertinent research program could be made on the basis of the review of the current program.

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| Proponent | SED |
| Evaluator | SED (J.K. Khosla) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $15K | $35K | $0K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 2.139.1 Aging of Cables in Nuclear Power Plant Environments

It is proposed: a) to assess the validity of accelerated aging methods for simulating the actual degradation of cable insulations in NPP environments; and b) to assess the ability of in-situ diagnostic techniques to determine the actual condition of cable insulation. The work would involve selection of appropriate electrical/control circuits, collection of data on experienced service environment, in-situ tests at NPD NGS, and laboratory tests and assessments at Ontario Hydro Research. This would be a joint project with Ontario Hydro with a total cost of $45,000.

Initial qualification of electrical and instrumentation cables for service in NPP environments involves preconditioning of cables by accelerated aging techniques before testing under postulated accident and post-accident conditions. Validation of the accelerated aging sequences can be made only by comparisons with naturally aged cables. Maintaining the operational readiness of NPP components throughout the plant lifetime requires an implementation of effective monitoring and maintenance methods. The proposed work would contribute to the development of such cable insulation monitoring methods.

Results of the proposed work would advance state-of-the-art knowledge related to qualification of cables, and would improve the AECB capability to assess the effectiveness of licensees' equipment qualification programs for electrical/instrumentation cables.

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|---|---|
| Proponent | SSS, SED |
| Evaluator | SED (T. Leung) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $12K | $0K | $0K | $12K |

Earlier Directly-Related Contracts and Funding:

## 2.140.1 Condition Monitoring of Electrical Motor Windings

It is proposed to assess the ability of various nondestructive diagnostic techniques to determine the actual condition and to predict the remaining life of high voltage motor windings. Three 2.3 kV motors of various ratings and applications would be removed from NPD NGS and tested first nondestructively and then destructively at Ontario Hydro Research Divison. This would be a joint project with Ontario Hydro with a total cost of $45K.

Reliability of electrical motors is essential for the safe and economic operation of nuclear power plants (NPPs). Recent failures of primary heat transport motor windings demonstrate the need for effective diagnostic techniques capable of detecting degradation of motor windings and predicting remaining life. Results of diagnostic tests (e.g. currently conducted at Pickering NGS) are presently difficult to assess. By comparing results of the nondestructive diagnostic tests to the destructive test results, the ability of the diagnostic tests to predict the remaining life of the electrical insulation of motor windings could be established.

The proposed work would advance the development of effective condition monitoring techniques for electrical motor windings. Its results would help the AECB to assess the results of motor tests conducted by licensees and would contribute to maintaining adequate reliability of various NPP systems.

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| Proponent | SED |
| Evaluator | SED (T. Leung) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $17K | $0K | $0K | $17K |

Earlier Directly-Related Contracts and Funding:

## 2.141.1 Ballooning of Heavily Hydrided Pressure Tubes

It is proposed to sponsor a project to perform creep tests and/or ballooning tests on heavily deuterided specimens cut from NPD pressure tubes. To be most useful, such tests would have to be performed at temperatures or temperature rates representative of a fuel channel in which coolant stagnation has occurred (25-30 degrees K/s).

It has been predicted that certain failures in reactor cooling systems could lead to coolant stagnation in fuel channels and to the ballooning and eventual rupture of pressure tubes. Such predictions must now be based on the properties of new pressure tube material which are ductile and low in dissolved deuterium. Irradiated and deuterided material is known to be more brittle and may experience a greater change in creep resistance.

The results of this project could lead to an improved ability to predict the strain at failure of rapidly creeping pressure tubes by confirming or developing hypotheses about the effects of irradiation and deuteriding of zirconium alloys. This would permit AECB staff to better assess predictions of pressure tube behaviour in accident situations.

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| Proponent | CQAD |
| Evaluator | CQAD (B. Jarman) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $100K | $0K | $0K | $100K |

Earlier Directly-Related Contracts and Funding:

## 2.142.1 Scraping Survey of NPD Pressure Tubes

It is proposed to sponsor a project to obtain samples, by "scraping", of a large number of pressure tubes in the NPD reactor. The deuterium concentration and oxide thickness of these samples would be measured and the results analyzed statistically in an attempt to reconcile observed variations.

Assumptions about the properties of irradiated pressure tubes are based on the results of destructive examinations on a relatively small number of tubes removed from reactors. These results show a surprising degree of tube-to-tube variation. If a large number of samples can be obtained by the scraping technique, which has been proposed for non-destructive examination of tubes in mature reactors, the scatter in the results could be correlated by statistical techniques with data from history dockets and other sources to determine its cause and significance.

The results of the project would assist AECB staff in: a) assessing the validity of sampling results obtained through the scraping technique; b) specifying non-destructive examination programs to be performed on mature reactors; and c) assessing predictions of probable failure frequency.

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| Proponent | CQAD |
| Evaluator | CQAD (B. Jarman) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $260K | $0K | $0K | $260K |

Earlier Directly-Related Contracts and Funding:

## 2.143.1 Mapping of NPD Rolled Joint Hydrides

It is proposed to sponsor a project to map the density and orientation of zirconium deuteride platelets in the rolled-joint region of an NPD pressure tube by sectioning the tube at the Zircaloy-steel interface.

Deuterium ingress, leading to deuteriding of the rolled-joint region of CANDU reactor pressure tubes, is a problem which is expected to lead to tube failures. The zircaloy tubes in NPD are believed to be heavily deuterided, but none have failed in service. Examination of such a tube could lead to: a) confirmation of current models of deuterium ingress; b) understanding of migration paths and platelet formation; and c) ability to predict material integrity from platelet orientation.

The results of the project could lead to confirming existing or developing new hypotheses about the integrity of pressure tubes in mature reactors. These would permit AECB staff to better assess predictions of pressure tube life expectancy.

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|---|---|
| Proponent | CQAD |
| Evaluator | CQAD (B. Jarman) |
| Project Manager | J. Pachner |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 2.144.1 Steam Generator Cooldown by Cold-Water Injection

It is proposed to conduct a critical review of the analytical methods used by licensees in analyses supporting the use of steam generators as a long-term heat sink under emergency conditions.

Cooling of the hot steam generator by low-pressure, cold-water injection is a complex process which involves several thermalhydraulic and two-phase phenomena such as rewetting, evaporation, reflooding, carryover, etc. An understanding of the factors that influence the behaviour of the two-phase flow through the narrow gaps within the steam generator is crucial in assuring that the steam generator can, in fact, be used as an acceptable long-term heat sink.

The outcome of the review would be used to evaluate assumptions used in licensees' submissions, and to determine whether further work is necessary in this area.

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|---|---|
| Proponent | SED |
| Evaluator | SED (Q.S. Truong) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $35K | $0K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

## 2.145.1 Defect-Sizing: Real Defects and Field Experience

It is proposed to obtain information on the abiity of the dB-drop ultrasonic technique to size real flaws (e.g. slag, fatigue cracks in welds, etc.), and to provide a summary review of the field experience of inspectors performing inaugural and in-service inspections using the dB-drop technique.

Ultrasonic flaw-sizing techniques addressed in ASME V have remained unchanged in principle for the last decade. The present ultrasonic dB-drop sizing methods are simply inadequate. The nuclear industry requires more accurate and repeatable results than those forthcoming from the present ASME standards. The periodic inspection reports show lack of repeatability and inaccuracy when this ultrasonic technique is used. Both industry and regulatory bodies recognize that additional work needs to be done in this area.

The resuls would be used in evaluating licensees' methods, and their repeatability and accuracy, when used in flaw detection and sizing.

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| Proponent | CQAD |
| Evaluator | CQAD (W. Grant) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $35K | $0K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 84.1.28 | $9000 | $0 | $0 | | $9000 |
| 85.1.9 | $35000 | $0 | $0 | | $35000 |

## 2.146.1 Cold-Water Injection in Two-Phase Flow Mixture

It is proposed to conduct a critical review of information related to the service experience of forces arising from cold coolant injection into a system containing two-phase fluid and the thermalhydraulic behaviour that causes such forces.

There have been several occurrances of significant load transients arising from interactions between cold coolant and two-phase environments. A recent incident involving the Bruce Unit-8 deaerator forms part of the CANDU reactor experience of such load transients. The project will enhance AECB understanding of the phenomena involved and will aid appraisal of the conditions necessary for the effective operation of safety systems.

The project will provide information with which to determine the ability of reactor system components to sustain dynamic loads which are likely to arise during the operation of coolant injection systems.

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| Proponent | CQAD |
| Evaluator | CQAD (K. Pereira), SED (Q.S. Truong) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $35K | $0K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

## 2.147.1 Permeability and Characteristics of NPD Concrete Specimens

It is proposed to acquire 6-inch, full-length concrete core specimens from the NPD reactor containment. The specimens would be used in an experimental program to investigate and measure their permeability to gas and water. The results would then be compared with those produced from laboratory prepared specimens. The project would also characterize pores and hydration products and examine the morphology, microstructure and lime-rich *interface to isolate* effects attributable to irradiation and to age. The cost for FY 87/88 would be expended on acquiring the concrete cores from the NPD reactor, decontaminating them, and delivering them to the University of Toronto.

This is the first time that naturally aged concrete would be tested in a Canadian laboratory for the purpose of studying the effects of age and service conditions on the properties of concrete used in nuclear power plant containment.

The results would be used to assess previous laboratory results, and be applied in evaluating the performance of reactor containment concrete over its service life.

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| Proponent | SSS |
| Evaluator | SED (K. Asmis) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | University of Toronto |
| Principal Investigator | R.H. Mills |
| Category | 1 * |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $10K | $40K | $30K | $15K | $95K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 84.1.1 | $95000 | $0 | $0 | | | $95000 |

## 2.148.1 Propagation Mechanisms of Molten Fuel/Moderator Interaction

It is proposed to join the NSERC in supporting the experimental investigations that are being carried out at McGill University on the propagation mechanisms of molten fuel/moderator interaction. The proposed program comprises experiments in which steam explosion will be triggered in arrays of molten tin drops immersed in water, and the subsequent propagation mechanism will be observed with high speed photography and fast response pressure instrumentation.

Overall knowledge of the controlling mechanisms for steam explosions resulting from the mixing of hot and cold liquids is poor at present. The proposed low-cost program would permit AECB staff to maintain awareness of current technical and scientific developments.

This program would provide useful background information to assist AECB staff in understanding this complex phenomenon and would assist in the resolution of relevant safety issues.

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| Proponent | SSS |
| Evaluator | SED (V.Q. Tang) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | McGill University |
| Principal Investigator | D. Frost |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $5K | $9K | $7K | $5K | $26K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 84.1.30 | $49000 | $0 | $0 | | $49000 |
| 2.095.2 | $4591 | $1789 | $0 | | $6380 |
| 2.120.1 | $0 | $34000 | $16000 | | $50000 |

## 2.149.1 Three-Dimensional Flow Behaviour in a CANDU Header

It is proposed to construct a low-pressure, low-temperature flow visualization loop to investigate the single-phase flow patterns in a representative scale CANDU reactor header. The loop would consist of a transparent header, several planes of feeders, a riser pipe and a recirculating pump. Dye injection techniques are proposed for flow visualization.

Understanding the single-phase flow behaviour in this manifold-like geometry is a prerequisite to any adequate modelling of the thermalhydraulics within a header. No similar work has ever been done or is being pursued by the industry. Great difficulties are being encountered in interpreting the results obtained from current experiments conducted by industry due to a basic lack of knowledge of the flow patterns even in single-phase flow.

The proposed research project would complement other large scale experiments conducted by the industry and could be easily extended to two-phase adiabatic conditions for an increased understanding of the basic phenomena involved.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (A.M.M. Aly) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| - | $0K | $0K | $50K | $0K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 2.150.1 Rejection Index for Pressure Tubes

It is proposed to study those properties of the zirconium alloy used in CANDU reactor pressure tubes which affect the tubes' fitness for service, and determine those property values which, if attained, would indicate the advisability of removing a tube from service.

The properties of reactor pressure tubes are subject to change during their service life as a result of the environment in which they are employed. While there are published criteria for accepting material for installation, there are none for rejection of tubes after irradiation. Examination of tubes which have failed in service has revealed certain changes in material characteristics which could be candidates for use as indicators of increasing susceptibility to failure.

The results of this study would be used by AECB staff in specifying non-destructive examination programs to be performed on mature reactors and in assessing the predictions of probable failure frequency derived from the results of such programs.

| | |
|---|---|
| Proponent | CQAD |
| Evaluator | CQAD (T.J. Molloy), DRR (Z. Domaratzki) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $80K | $0K | $0K | $80K |

Earlier Directly-Related Contracts and Funding:

## 2.151.1 International Nuclear Liability Review

It is proposed to conduct reviews of the foreign national and international liability regimes, and to compare and analyze the findings of each review in relation to the Canadian Nuclear Liability Act.

In preparation for a pending court action concerning the Canadian Nuclear Liability Act, it is required to evaluate comparatively this Act against other international and foreign-national liability regimes for the Attorney General of Canada and if possible to identify potential witnesses capable of satisfactorily testifying in court in Canada concerning that analysis and evaluation.

The findings will be used to support the response of the Attorney General of Canada to litigation challenging the validity of the Nuclear Liability Act.

| | |
|---|---|
| Proponent | LSU |
| Evaluator | LSU (P. Barker) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $0K | $0K | $0K | $0K |

Earlier Directly-Related Contracts and Funding:

## 2.152.1 Implementation of CATHENA on AECB Apollo Computer

It is proposed that WNRE prepare detailed, and documented, CATHENA input files for two test facilities and a CANDU 600 for the use of AECB staff when the code is run on the AECB Apollo computer. These input files are currently in use on WNRE's VAX system; however, the contents are not documented and slight modifications are required to install them on the Apollo machine.

This work is required to enable AECB staff to use the advanced two-fluid code CATHENA to analyze experimental results by performing pre- or post-predictions using the geometries of the test facilities. In addition, the 600 MW file contains the most up-to-date geometry of the CANDU 600 including simulation of the secondary side. Compilation of the same data files by AECB staff using the design information would take a significantly longer time.

A comparison of CATHENA predictions with experimental results would give AECB staff a better appreciation of the phenomena involved in loss of coolant accidents. CATHENA, with the latest simulation of a CANDU reactor, would give AECB staff an independant tool to assess various accident analyses. The documentation of various test facilities and their idealization for CATHENA would provide a useful and stand-alone report which could be used to assess the validation of other computer codes such as SOPHT, FIREBIRD or TUF.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (Q.S. Truong) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | Atomic Energy of Canada Ltd. - WNRE |
| Principal Investigator | D.J. Richards |
| Category | 1 * |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $8K | $22K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 86.1.22 | $16441 | $0 | $0 | | | $16441 |

## 2.153.1 Computer Codes for Examining Circulation within Containment

It is proposed to acquire the computer code COBRA-NC and convert it to work on one of the AECB in-house computers. The code would be used to examine events such as LOCA and LOECC specifically to determine post-event hydrogen distribution within containment.

In safety analyses for LOCA and LOECC, the concentration of the hydrogen released inside the containment is assumed to be uniform. This assumption needs to be confirmed particularly when cooling fans are not credited. Hydrogen concentration distribution within the containment is an important parameter in taking the decision of when the ignitors be initiated.

The outcome of this study would be used in evaluating the consequences of a hydrogen burn, and the appropriateness of the locations of the hydrogen ignitors within the containment.

| | |
|---|---|
| Proponent | SED |
| Evaluator | SED (J. Khosla) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $20K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 2.154.2 Measurement of RBE for Tritium for Myeloid Leukemia

It is proposed to continue funding the laboratory experiment to measure the Relative Biological Effectiveness for tritium beta rays for the induction of myeloid leukemia in mice.

The study was proposed because of the concern as to whether or not a given dose of tritium beta rays is equally as effective as the same dose of 200 kVp X-rays, delivered at the same dose rates, for the induction of myeloid leukemia. A feasibility study completed in FY 84/85 has recommended a full-scale 5-year study on CBA/H mice. Note: Due to the breakdown of the 300 kVcp generator, the study is being performed using a suitably filtered 150 kVcp X-ray beam. This is not anticipated to undermine the validity of the results.

It is anticipated that the results of the study will improve the estimate of the quality factor (QF) for tritium beta rays. (This is a joint study with AECL, Ontario Hydro, Hydro Quebec and NBEPC. The total cost of the study is $1,221.7K; the share breakdown is: AECB $335K, AECL $574.3K, Utility Group $312.4K.)

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|---|---|
| Proponent | RPD, HRS |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | E. Rabin |
| Panel | 6 |
| Contractor | AECL-CRNL |
| Principal Investigator | J.R. Johnson |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $94K | $64K | $80K | $97K | $0K | $335K |

Earlier Directly-Related Contracts and Funding:

## 2.155.1 Maintenance: Means and Methods

It is proposed to conduct a critical survey of the methods, procedures and techniques of maintenance used to ensure the adequacy and determine the status of equipment performance while on-line. The study will cover nuclear and non-nuclear industries. The proposed survey would include detailed description of various maintenance techniques such as preventive, predictive and corrective maintenance.

According to the independent assessments by staff of the utilities and the AECB, inadequate maintenance is the primary cause of numerous significant events. A project that would review and possibly suggest improvements to the current maintenance programs is proposed. Such a project would address, inter alia, the following aspects: a) the frequency of maintenance performed on equipment; b) adequacy of maintenance procedures - conformance with manufacturers' recommendations/requirements; and c) qualifications and training of maintenance personnel. In a first phase, the review will focus on maintenance programs/practices in countries other than Canada.

The results would be used in assisting AECB staff in judging compliance with those licence requirements related to plant maintenance.

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|---|---|
| Proponent | SSS |
| Evaluator | PRDB (G. Ishack) |
| Project Manager | A. Omar |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 2.156.1 Assessment of Significance of Organically Bound Tritium

It is proposed to critically assess the information available in the scientific literature concerning the pathway for organically bound tritium (OBT) through the environment to humans.

There have been many measurements of organically-bound tritium/tritiated water (OBT/HTD) ratios in environmental samples and food. Generally ratios in the range 1-5 have been noted although much higher values have also been observed. Considerable caution is advisable in drawing conclusions from these data because of the difficulty in measuring and interpeting OBT results at environmental levels. A critical in-depth assessment of this information is therefore needed.

Tritium is a relatively important radionuclide that is released through atmospheric and aquatic pathway from CANDU nuclear generating stations (NGSs). These releases are limited by the regulatory body through the setting of derived release limits which are calculated values based on the dose limit for members of the public. These calculations involve quantifying the pathway for tritium (HTO, OBT) through the environment to humans. The results of this review would provide greater confidence to AECB staff in regard to the derived release limits for tritium at NGSs.

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|---|---|
| Proponent | RPD |
| Evaluator | RPD (C. Letourneau) |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $11K | $0K | $0K | $11K |

Earlier Directly-Related Contracts and Funding:

## 2.157.1 Consequences of Severe Accidents in Canadian Power Reactors

It is proposed to perform a study of the consequences of postulated severe accidents at Canadian nuclear generating stations (NGS). "Severe accidents" are accidents which are more severe than the so-called "design-basis accidents" which currently form the basis for AECB licensing of nuclear power reactors. The first phase of the study would be based on the Pickering A NGS. The severe accidents to be studied *initially* would include the current *menu* of single and dual failures *not* involving containment impairment, combined with various modes of containment failure, including modes not currently considered in licensing. Where data are supported by some degree of validation, analyses would be done on a "best estimate" basis; that is, by selecting the best estimate of, or most likely values for, parameters influencing the consequences, or by selecting a range of values for parameters which are known to vary considerably, e.g., weather conditions. The study would include both the short term and long term consequnces and local, regional and global impacts. Subsequent phases of the study would include similar considerations at other Canadian NGS of different designs and locations.

The study is proposed because of increased public skepticism about the industry claims regarding the low probability of severe accidents in the wake of the Three Mile Island and Chernobyl accidents. On the other hand experience from the Three Mile Island accident, which is probably more relevant to Canadian reactors than the Chernobyl accident, demonstrated that existing safety analyses may be unduly pessimistic in predicting consequences.

The information obtained from this study would be useful to the AECB and to governments for developing advice or making decisions regarding nuclear insurance or siting policy for large power reactors.

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|---|---|
| Proponent | ACNS |
| Evaluator | DRR (Z. Domaratzki) |
| Project Manager | A. Omar |
| Panel | 14 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $100K | $50K | $200K | $350K |

Earlier Directly-Related Contracts and Funding:

## 2.158.1 Evaluation of Functional Specification Review Techniques

It is proposed to apply knowledge representation and expert system techniques to the safety evaluation of a nuclear power plant system. The system to be reviewed would be the trip computer software for Shutdown System 1 of the Darlington Nuclear Generating Station. Knowledge representation and expert system techniques would be used to transform the functional specification document into a database of rules via a symbolic programming language such as LISP or Prolog. This database would be analyzed for such characteristics as precision, lack of ambiguity, consistency and completeness.

The majority of software faults are due to deficiencies in the functional specification. Checking of the functional specification currently is based primarily on informal inspection. However, the program design, coding, and testing all rely on a thorough functional specification. The Darlington Shutdown Systems rely completely on software so it is essential that the integrity of the trip computer functional specifications be established.

This study will introduce AECB staff to the application of knowledge representation and expert system techniques. The resulting representation of the SDS-1 trip computer functional specification may also be used to model the behaviour of the system for reactor safety analysis and to assess the effectiveness of the licensee's test data sets.

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|---|---|
| Proponent | SED |
| Evaluator | SED (C. Downie, R. Ferch, J. Kendall) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

## 2.159.1 Methods for Review of Training Programs at Nuclear Plants

It is proposed to initiate a project to review existing methods, and to develop/adapt optimum methods and standards, for the review of licensees' training programs for nuclear power plant operating personnel.

The project is prompted by experience with recent reviews of training programs at a nuclear power plant nearing construction completion. The reviews have identified needs for and have led to significant changes and improvements in the programs. The plans and methods for these reviews had been prepared on a case by case basis. While productive, the preparation, execution and reporting have required a heavy input from senior level personnel, leading to large workloads for these senior people.

Results of this project would be applied in future reviews. It is hoped that with the application of suitable methods and procedures such reviews could be planned and executed with less senior personnel input than at present, yet with full retention and possibly improvement in effectiveness.

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|---|---|
| Proponent | OCRFD |
| Evaluator | OCRFD (F. Davediuk) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 2.160.1 Dose Calculations under Transient Conditions

It is proposed to fund a contract to calculate, for a specific reactor site, the individual and population doses for the spectrum of release scenarios defined in the reactor Safety Report. The principal variables of interest are: source release characteristics, weather conditions, and population distribution. It is proposed that CRAC-II (Calculation of Reactor Accident Consequences - Version 2) computer code should be used for this study. Also, this code should be set up on the AECB computer system for later use in assessment of licensee's submissions as well as comparison with ONSR's study on health and economic consequences.

Historically, dose calculations for accidental airborne releases at reactor sites use simple and overly-conservative assumptions, such as steady-state release, most severe weather conditions, and fixed receptor location. Information is required with which to calculate more realistic estimates of dose.

The results of the project would be used in the assessment of licensee submissions on accident conditions involving airborne releases, and in gaining experience with previously-recommended "default" weather scenarios. The results of the sensitivity studies will be used to estimate bounding values of model parameters which are expected to be treated probabilistically in licensee submissions on Darlington NGS.

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|---|---|
| Proponent | SED |
| Evaluator | SED (L. Truong), RPD |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $70K | $0K | $0K | $70K |

Earlier Directly-Related Contracts and Funding:

## 2.161.1 Expert Systems as A Decision Tool

It is proposed that a pilot project be undertaken to investigate the use of expert systems as a decision tool in the Reactor Regulation Directorate.

Reactor licensing decisions are frequently based on the application of the rules and requirements which have evolved from Regulations. By incorporating these into a FRAME-based expert system which recognizes hierarchical precedence and dependencies a decision tool could be devised. Such a computer-aided device would permit alternative licensing paths to be considered and could incorporate new requirements as they were evolved. An improved level of accountability could be achieved by recording the pathways used in past licensing decisions. NOTE: Rather than using predicate logic (PROLOG), this project would examine the possibility of using FRAMES for knowledge representation. FRAMES are used extensively in LISP-based logic processing, especially in North America.

The results of the project would be used to evaluate the potential for use of Expert Systems in the Reactor Regulation Directorate.

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|---|---|
| Proponent | SED |
| Evaluator | SED (C. Downie) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 2.162.1 Childhood Leukemia around Canadian Nuclear Facilities

It is proposed to conduct an epidemiological study of leukemia among children born in the vicinity of Canadian nuclear facilities. In the initial part of this study, the incidence of leukemia among children born within a radius of a few kilometres of the nuclear facilities at Pickering, Chalk River and Rolphton, and Port Hope, Ontario, will be compared with the corresponding incidence of childhood leukemia among suitably selected control groups. Potential doses to the children in the vicinity of the nuclear facilities will be estimated using data from liquid and airborne radioactive releases from the facilities, and from environmental monitoring data where available.

This project is proposed because of some concern in the literature that children born in the vicinity of nuclear facilities might show an elevated incidence of leukemia (Brit. Med. Journal 295, 822-827, 1987). It is therefore important to find out whether such concern is applicable to the children born in the vicinity of Canadian nuclear facilities.

It is anticipated that the results of this study will clarify the concern as to whether or not there exists any clustering of childhood leukemia in the vicinity of these nuclear facilities. If there is an indication of the existence of any statistically significant clustering, then a detailed study at these and other nuclear facilities in Canada will be proposed to examine the influence of radiation doses and any other factors, such as exposure to chemicals present in the environment, on the incidence of childhood leukemia.

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|---|---|
| Proponent | ACRP, RPD |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | V. Elaguppillai |
| Panel | 2 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $45K | $35K | $0K | $80K |

Earlier Directly-Related Contracts and Funding:

## 3.103.1 Absorbed Fraction of Ingested Uranium in Humans

It is proposed to determine the absorbed fraction of ingested dietary uranium in humans, including those persons living in uranium mining communities, by measuring the content of uranium in their diet and in their fecal and urinary excretions.

The currently used annual limit on intake (ALI) for uranium, by ingestion, is derived using a value of 0.05 for the absorbed fraction of ingested uranium. This fraction is known to have a number of uncertainties, and more work should be done to improve its accuracy.

The results of the study are expected to improve the value for the absorbed fraction and hence the estimate of the ALI for uranium.

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|---|---|
| Proponent | RPD |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $60K | $20K | $0K | $80K |

Earlier Directly-Related Contracts and Funding:

## 3.104.1 Neotectonic Conditions in Eastern Canada - Phase I

It is proposed to participate in, and contribute to, a Federal-Provincial Working Group, the formation of which is to address geologic conditions and, ultimately, the issue of seismic risk in eastern Canada. The group, known as MAGNEC (Multi-Agency Group for Neotectonics in Eastern Canada), will comprise the Geological Survey of Canada (the coordinating agency), the Ontario Geological Survey, Ontario Hydro, the Ontario Centre for Remote Sensing, and the AECB. Perhaps, Hydro Quebec, the New Brunswick Department of Natural Resources and Energy and the Nova Scotia Department of Mines and Energy will also join. Except for the AECB, and possibly Ontario Hydro, all participating agencies are expected to contribute staff effort, rather than money, to the program.

This program, and AECB participation in it, are proposed because, to date, the assessment of seismic risk has relied solely upon documenting and evaluating historical and current seismic data. This approach has limited value because it is based on the assumption that future earthquakes will occur in areas of past events. Therefore, if a nuclear facility is planned for an area in which earthquakes have not been documented, it is conceivable that the probability of occurrence of a major, disastrous earthquake will be underestimated. Consequently, the design of a nuclear facility to withstand an earthquake may be inadequate.

It is anticipated that the results of this entire program will provide the AECB with appropriate information for establishing a regulatory position addressing all aspects of seismic risk. The results are also anticipated to be useful in assessing the thoroughness of work undertaken, as well as claims made, by licensees in this particular study area.

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|---|---|
| Proponent | SSS |
| Evaluator | SSS; DRR |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | Energy, Mines & Resources Canada |
| Principal Investigator | |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $40K | $0K | $75K | $75K | $190K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 3.127.1 | $0 | $0 | $6000 | | $6000 |
| 3.128.1 | $0 | $0 | $20000 | | $20000 |
| 3.129.1 | $0 | $10000 | $10000 | | $20000 |
| 3.130.1 | $0 | $0 | $15000 | | $15000 |
| 3.131.1 | $0 | $25000 | $25000 | | $50000 |

## 3.106.3 Transfer of Radionuclides to Human Milk - Phase 3 Field Study

It is proposed to conduct a full-scale sampling and analytical program to determine the concentration factors for the uranium and thorium decay chains in the pathway from food to human milk. A feasibility study (3.106.2) is being currently undertaken to identify and test techniques for determining the very low levels of radioisotopes found in human milk samples and to recommend a detailed plan for a full scale sampling program.

A literature survey conducted for the AECB (INFO 0192) has shown that little information exists on the transfer of radionuclides via the human milk pathway. As part of an ongoing review, the AECB has therefore decided to conduct research to determine whether this is a significant pathway.

It is anticipated that the results of the study will enable the AECB to determine the importance of human milk in radionuclide transfer and, consequently, its significance in the derivation of release limits for nuclear facilities, such as uranium mines and mills.

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|---|---|
| Proponent | RPD |
| Evaluator | RPD (C. Letourneau) |
| Project Manager | R. Avadhanula |
| Panel | 11 |
| Contractor | |
| Principal Investigator | |
| Category | 2 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $60K | $60K | $0K | $120K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 84.4.17 | $30000 | $0 | $0 | | $30000 |
| 86.4.9 | $0 | $40000 | $0 | | $40000 |

## 3.107.1 Stresses to Induce Failure across Faults and Fractures

It is proposed to inject fluids into existing faults and fractures, in the Roblindale Quarry, to determine the stress differential required to induce movement along the faults and fractures and, possibly, seismic activity.

This study is proposed to determine whether or not the ambient stress conditions in the quarry as measured in related projects by Ontario Hydro under contract to the AECB (84.4.9, 85.4.14, 86.4.1) are such that slippage along the fractures and faults is likely to occur there in the relatively near future. Such a determination would provide an indication of the tectonic stability in that quarry and in the region, as well as a general indication of tectonic stability in eastern Canada.

It is anticipated that the results of this study will be used, in conjunction with the results of other studies, to acquire sufficient relevant information about tectonic and seismic conditions in eastern Canada. These results would then be used, in turn, to evaluate claims made by licensees regarding tectonic stability at relevant sites.

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|---|---|
| Proponent | SSS |
| Evaluator | DRR; SSS |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | Fracflow Consultants Ltd. |
| Principal Investigator | |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $40K | $8K | $0K | $0K | $48K |

Earlier Directly-Related Contracts and Funding:

## 3.111.1 Evaluation of Data and Models on Uranium Metabolism

It is proposed to continue to fund the compilation of currently known data regarding the intake, transfer (among organs), retention, and excretion rates of uranium in uranium workers, with a view to testing currently available metabolic and dosimetric models with different data sets, to comparing computed excretion patterns to the observed ones, and to determining which model describes best the known data (or how a selected model should be modified to fit the observed data).

Several models for uranium metabolism exist at present, but none seems to describe realistically uranium transfer, retention, and excretion rates in humans. Since individual doses from occupational uranium intake are generally determined from the interpretation of bioassay data (urinalysis), it is critical that the AECB Radiation Protection Division identify and acquire a reliable tool for dose calculation in the case of exposure to uranium compounds.

It is anticipated that the study will assist in identifying and in providing the AECB staff with the state-of-the-art metabolic and dosimetric model for uranium intake. (The overall study will be conducted in two phases which will be contracted out separately. Phase I will deal with data collection, review and evaluation; Phase II will consist of testing, selecting and, if necessary, adapting metabolic models for AECB purposes. The estimated cost of Phase II is $60K. The costs shown for Project 3.111.1 concern Phase I only. Board approval was obtained for both phases on April 30, 1987, BMD 87-51.)

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|---|---|
| Proponent | RPD |
| Evaluator | RPD (F. Horvath) |
| Project Manager | P. Duport |
| Panel | 4 |
| Contractor | |
| Principal Investigator | |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $5K | $65K | $0K | $0K | $70K |

Earlier Directly-Related Contracts and Funding:

## 3.115.1 Neutron Dosimeters and Survey Meters in Accelerators (I)

It is proposed to fund a project to determine which type(s) of neutron dosimeters for personal dose assessments and survey meters for radiation exposure control is (are) "best suited" for use at certain nuclear facilities (mainly particle accelerators) and in some applications involving radioisotopes where measurable neutron doses can be received by workers. "Best suited" refers to best energy response (flatness of energy response curve) over the energy range (thermal to possibly several hundred MeV) of neutrons responsible for (most of) the dose received and least affected by the environmental conditions (e.g. temperature, humidity, rf fields, etc.) at the work sites. In addition, response to mixed neutron and gamma fields, and to pulsed neutron fields may have to be considered; and ease of calibration, accuracy and reliability will be addressed in this work. Phase I of this study will be performed as follows. By means of discussions with AECB project officers and staff at identified facilities and for specific radioisotope users, and from a thorough search of the open literature, the research team will obtain spectral information on the neutron fields at occupied areas in the work place. The characteristics of neutron dosimeters and survey meters will be obtained from the manufacturers of the instruments and from the open literature. Phase II of the project (3.115.2) will, by means of laboratory and field testing, complement the work of Phase I, by providing information not obtainable in the first phase.

This project is proposed because neutron fields at AECB licensed facilities (mainly particle accelerators) may result in significant exposures to workers. On several occasions, it was found that the type of dosimeter or survey meter used at an accelerator facility or in applications involving radioisotopes was inappropriate for measuring exposure from the particular spectrum of neutron energies present. The findings of this study will provide guidance to AECB staff and licensee personnel with respect to ensuring that appropriate neutron monitoring devices are used.

It is anticipated that the findings of this study will be instrumental in the preparation of a regulatory guide for use by AECB staff and licensees if the selection of appropriate instrumentation for radiation protection purposes. As a consequence, an improvement in the accuracy of neutron dosimetry in Canada is likely to be realized.

| | |
|---|---|
| Proponent | RPD |
| Evaluator | RPD (G.S. Poirier), PRDA (M.F. James) |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 3.115.2 Neutron Dosimeters and Survey Meters in Accelerators (II)

It is proposed to fund a project that, by means of laboratory and field tests, will provide information on the neutron spectra at occupied areas in AECB licensed facilities and on neutron dosimeter/survey meter suitability, where such information does not exist. In addition side-by-side testing of the most suitable neutron detectors for each type of facility and use listed in Phase I (3.115.1) will be carried out either at the facilities/workplaces or in the laboratory under conditions of exposure that simulate working conditions at the facilities/workplaces.

This project is proposed to augment the information obtained in Phase I. Performance of this project is therefore conditional upon the findings of Phase I.

It is anticipated that the results arising from an examination of the neutron spectra together with the evaluation of neutron dosimeters and survey meters will result in an optimized use of such equipment.

| | |
|---|---|
| Proponent | RPD |
| Evaluator | RPD (G.S. Poirier) |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $20K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 3.116.1 Radiation Sensitivity of Organisms Other than Man: A Review

It is proposed to review and evaluate the scientific literature upon which rests the assumption that if humans are adequately protected from undue exposures to ionizing radiation then other species are also likely to be sufficiently protected. The estimated cost of this project is $70K to which Environment Canada has agreed to contribute $15K.

Results of several studies have raised concerns among national and international groups as to whether populations of organisms other than humans are indeed adequately protected at the level considered adequate for members of the public. A thorough understanding of the radiation sensitivity of species of organisms other than humans is therefore most essential for planning and regulating the protection of the environment.

The results of this project would be used to ensure that environmental radiation protection principles are based on rational and systematically-developed assumptions and measurements.

| | |
|---|---|
| Proponent | RPD |
| Evaluator | RPD (R. Chatterjee) |
| Project Manager | R. Avadhanula |
| Panel | 11 |
| Contractor | |
| Principal Investigator | |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $55K | $0K | $0K | $55K |

Earlier Directly-Related Contracts and Funding:

## 3.121.1 BIOMOVS - Intercomparison of Environmental Assessment

It is proposed to collaborate with Atomic Energy of Canada Ltd. (AECL) in supporting Canadian participation in an international intercomparison of environmental assessment models and their predictions, a program called BIOMOVS, which is organized by the Swedish International Institute of Radiation Protection (NIRP) in cooperation with the Nordic Liaison Committee for Atomic Energy. It is also proposed that Canadian experts participate in the exchange of ideas, Canadian experience and information to improve the confidence with which the environmental behaviour of radionuclides in the biosphere can be assessed quantitatively. The estimated total cost of the two-year program to be shared by AECL and AECB is $125K.

Environmental and pathways analysis models are used by AECB licensees to derive release limits for nuclear facilities and to predict doses to members of the public from waste management practices. The assessment of the possible consequences of the release of radionuclides often depends entirely on the predictions of mathematical models. Because the model predictions are subject to uncertainty, their reliability must be evaluated. It is well recognized that the evaluation of the reliability of model predictions requires a variety of tests involving comparisons of model predictions against independent data sets over a range of environmental conditions and intercomparison of the predictions made by different models. Participants in BIOMOVS project plan to test the accuracy of the predictions of environmental assessment models for selected contaminants and exposure scenarios to explain differences in model predictions due to structural deficiencies, invalid assumptions, and/or differences in selected input data, and to recommend priorities for future research to improve the accuracy of model predictions.

Involvement of Canadian experts in this intercomparison is important in ensuring credibility to modelling activities in Canada and regulatory decisions based on such modelling. A collaborative involvement of CRNL staff and AECB staff will help in gaining an appreciation of the validity of terrestrial and aquatic models in general and Canadian models in particular. Improvements in modelling soundness will stem from this.

| | |
|---|---|
| Proponent | RPD |
| Evaluator | RPD (R.M. Chatterjee) |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | Atomic Energy of Canada Ltd. (CRNL) |
| Principal Investigator | P.J. Barry |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $5K | $30K | $0K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

## 3.122.1 Study of the Effect of Uranium on Kidney Function

It is proposed to study, in an animal species and in man, the changes induced in kidney function by inhaled or ingested uranium. The study would be conducted in four phases: Phase I - literature review and status of current research, with an emphasis on the identification of the animal(s) that best model(s) human kidney response to uranium; Phase II - depending upon the findings and conclusions of Phase I, determination of the relationship between kidney functions, uranium intake and kidney burden in the animal species, identified in Phase I, and the recovery rate of kidney tissue following the initial damage; Phase III - feasibility study of monitoring kidney function in uranium workers; and Phase IV - design and implementation of a large-scale study of kidney function as a marker of kidney damage and hence of uranium intake in uranium workers. Phase II and III can be conducted simultaneously.

The chemical toxicity of inhaled or ingested soluble uranium, especially its nephrotoxicity, surpasses its radiotoxicity. Therefore, occupational exposure to soluble uranium will primarily affect kidney tissues. However, human kidneys have a functional overcapacity of a factor of six, and kidney functions may be significantly altered before any clinical evidence of tissue damage is perceived. Also, intakes of soluble uranium are rapidly eliminated, and standard albumin tests are considered to be insufficiently sensitive for evaluating long-term sub-clinical kidney damage. Recent publications indicate that more sensitive tests are now available. It has been suggested that kidney damage resulting from uranium intake may exist for a long time without clinical evidence of damage, and may be detectable long after the intake, when uranium concentration in urine is back to naturally occurring levels. Therefore, there seems to be a possibility to use the measurement of kidney functions (i.e., urine content of proteins, alpha amin-nitrogen, plasma urea nitrogen, N-acetyl beta-glucosaminidase, and possibly other substances) as an indicator of long-term kidney damage and hence of exposure to uranium. In order to master this monitoring technique, it is necessary to begin with the study in an animal species to determine the variation of urinary function indices as a function of uranium intake and as a function of time after the intake, and to assess the extent of detectable non-clinical kidney disfunction among uranium workers.

It is anticipated that the results of Phases II and III will indicate whether enough detectable sub-clinical deterioration of kidney function occurs in workers occupationally exposed to uranium and will also indicate whether a large-scale human study (Phase IV) involving a complementary systematic search for bioindicators of kidney damage before clinically evident disfunction is warranted. (The decision to undertake Phases II, III and IV will be made according to the findings of the preceding phase(s) and the recommendations of the Review Panel. The project will begin with Phase I at a cost of $25K. Phase II and/or Phase III will be initiated if warranted by the findings and conclusions of Phase I.)

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|---|---|
| Proponent | RPD, HRS |
| Evaluator | RPD (C. Pomroy, F. Horvath) |
| Project Manager | E. Rabin |
| Panel | 9 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $90K | $140K | $280K |

Earlier Directly-Related Contracts and Funding:

## 3.123.1 Influence of Macrophages on Dissolution of Uranium Compounds

It is proposed to study, in the laboratory, the influence of human and rodent macrophages on the in vitro dissolution rates of uranium compounds, as a function of the chemical forms and particle sizes of these compounds. (Macrophages are specialized cells whose function is to destroy bacteria and foreign materials that enter an organism.)

Experimental data on the biokinetics of uranium in man are not consistently compatible with in vitro solubility rates of the same compounds which are widely used in current dosimetric models. Recent information from laboratories of the French Atomic Energy Commission (Service of Experimental Pathology) indicates that the solubility rate of uranium compounds is significantly enhanced by the presence of macrophages in simulated lung fluid, and that this enhancement depends on the animal species from which the macrophages are obtained. The solubility rate of radioactive material is an important parameter of metabolic and dosimetric models, and it is necessary that AECB staff know, and use, the most realistic and accurate parameters in these models, whether for determining regulatory exposure limits or for deriving bioassay guidelines for accidental or routine radiation exposures. The proposed study would be conducted in two phases: Phase I - critical review of the literature and status of current research; and Phase II - experimental comparison of the dissolution rate of uranium compounds in simulated lung fluid, with and without animal and human macrophages, with a view to determining the enhancement factor due to the presence of macrophages. The knowledge of the enhancement factor is important because it will allow the determination of dissolution rates from the more economical simulated lung-fluid-only technique; it will also allow a re-interpretation to be made of past dissolution studies and of their consequences.

It is anticipated that the results of the study will provide the AECB with realistic solubility parameters to be used for the determination of bioassay guidelines, and for exposure and dose calculations. (The project would begin with Phase I at a cost of $25K. Phase II will be initiated upon positive conclusions of Phase I, positive recommendations of the Review Panel, and agreement by the AECB proponent division.)

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|---|---|
| Proponent | HRS, RPD |
| Evaluator | RPD (F. Horvath) |
| Project Manager | P. Duport |
| Panel | 5 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $40K | $0K | $90K |

Earlier Directly-Related Contracts and Funding:

## 3.124.1 Assessment of Errors in Airflow-Measuring Instruments

It is proposed to determine theoretically and experimentally (in the laboratory) the errors and uncertainties associated with the the measurement of airflow rate in air monitoring instruments with a view to evaluating the contributions of these errors to the overall uncertainties attached to the measurements of airborne radioactivity.

Current methods used to determine the concentration of airborne radioactive materials are based on the use of fixed or portable instruments that draw a volume of air through a filter. The air concentration of radioactive material is calculated from the activity collected on the filter and from the total volume of air drawn through the filter. Since sampling apparatus is generally not equipped with a time integrating meter, the volume of air sampled is derived from a short-time airflow rate measurement. Airflow rates are measured with a variety of instruments that are based on different principles (bubble tube, rotameter, mass flow meter, wet test meter, hot-wire flow meter) and respond differently to changes in pressure and temperature. Sometimes, sampling equipment is tested in the laboratory, under pressure and temperature conditions different from those encountered in the field. Some pumps produce a pulsated flow that may affect the response of certain types of flow meters. All the above affect the reliability and comparability of airflow measurements which are made to calibrate sampling systems. Although the determination of uncertainties and errors in radiation counting have been thoroughly documented, the contribution of errors and uncertainties attached to airflow measurements has never been studied in the context of air monitoring for radiation protection purposes. The knowledge of these errors is necessary to evaluate the accuracy and reliability of "air quality" data collected in mines, mills, and other facilities in which airborne radioactivity is a hazard.

It is anticipated that the study will identify the sources of error and the magnitude of the uncertainties attached to airflow rate measurements that are used together with radiation counting to measure the activity concentration of radionuclides in air. It will therefore allow AECB staff to compare and assess the reliability and accuracy of monitoring data provided to the AECB, by its licensees, as evidence of compliance with the relevant licences and regulations.

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|---|---|
| Proponent | HRS, UMD |
| Evaluator | UMD (R. McCabe) |
| Project Manager | P. Duport |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $40K | $0K | $0K | $40K |

Earlier Directly-Related Contracts and Funding:

## 3.125.1 Study of Chemical Toxicity of Uranium Hexafluoride

It is proposed to investigate the chemically toxic effects in humans, from accidental acute releases of uranium hexafluoride in uranium conversion plants.

The chemical toxicity of uranium and fluorine are known individually. However, during an accidental release of uranium hexafluoride in a conversion plant, it is probable that an acute uptake of uranium by workers will be associated with an acute uptake of the fluoride. The tests to determine if a worker may have suffered damage to his organs are based primarily on the results of uranium excretion patterns and kidney function assessments. This work is proposed because it appears that there is insufficient information available on the toxic effects due to the combination of uranium and fluorine in the compound uranium hexafluoride.

It is anticipated that the proposed research will provide information on the health effects of uranium hexafluoride on humans from accidental acute releases in conversion plants. The gathered information may also be used in the development of action level guidelines concerning the return of acutely-exposed workers to their normal duties. (This project will begin with a literature review; if insufficient information is found, then an animal study will be considered to gather the required information. The costs below reflect the estimated cost for a literature review only.)

| | |
|---|---|
| Proponent | FHWD, RPD |
| Evaluator | FHWD (A. Ghosh), RPD |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $20K | $0K | $0K | $20K |

Earlier Directly-Related Contracts and Funding:

## 3.126.1 Estimation of Fluoride by Lime Candles - A Review

It is proposed to conduct a literature review to determine and recommend the most appropriate conversion factors with which to estimate both low and high concentrations of fluoride in air, based on the deposition of fluoride on lime-coated filters (lime candle method). It is also proposed to evaluate critically the factors that limit the use of the lime candle method in estimating fluoride concentrations in air.

Under normal operations, small amounts of fluoride in gaseous form are released to the environment during the uranium hexafluoride conversion process. Because large volumes of hydrogen fluoride and uranium hexafluoride are handled during these operations, the potential exists for a large release of fluoride to the environment. The purpose of this project is to verify that the lime candle method and the conversion factors currently in use are suitable for measuring fluoride in the environment should such a large accidental release occur from a licensed facility.

The results of this study would be useful to AECB staff in reviewing assessments of the possible impact of large accidental releases of fluoride on the environment and on public health.

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| Proponent | FWD |
| Evaluator | FWD (A. Ghosh), RPD |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 3.127.1 Displacements of Glacial Striations, Saint John, N.B.

It is proposed to map, in detail, exposures of slate in Saint John, N.B., showing displacements of glacial striae across slaty cleavage which are, in effect, small-scale faults. Some, but not all, striae serve as excellent markers of the three-dimensional movement along fault surfaces.

This study is proposed to provide well-documented data on the nature, and amount of displacement, of geologically young movements. This study is one of several to be funded under the auspices of the MAGNEC program.

The results of this study will add to the geological component of the data base on neotectonics, which is essential in order to improve the estimate of seismic risk in eastern Canada.

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|---|---|
| Proponent | J.L. Wallach |
| Evaluator | DRR (Z. Domaratzki), SSS (J.L. Wallach) |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | University of New Brunswick |
| Principal Investigator | K.B.S. Burke |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $6K | $50K | $0K | $56K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 3.104.1 | $0 | $40000 | $0 | | $40000 |
| | $0 | $0 | $0 | | $0 |
| 3.128.1 | $0 | $0 | $20000 | | $20000 |
| 3.129.1 | $0 | $10000 | $10000 | | $20000 |
| 3.130.1 | $0 | $0 | $15000 | | $15000 |

## 3.128.1 Fault Investigation - Miramichi Area, N.B.

It is proposed to expose bedrock in an area where lineaments have been identified, a fault is suspected, and seismic events, related to the M5.7 earthquake that occurred in this area in 1982, have been rather precisely located.

This study is proposed to see if the fault or fault zone, movement along which produced the large earthquake and several large aftershocks, shows displacement at the surface.

It is anticipated that the results of this study will be the discovery of a seismogenic source which has a surface expression or some distinct signature. If successful the results will be useful in identifying other faults which may have generated seismic activity prior to the period for which historical records exist.

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|---|---|
| Proponent | J.L. Wallach |
| Evaluator | DRR (Z. Domaratzki), SSS (J.L. Wallach) |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $20K | $85K | $0K | $105K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 3.104.1 | $0 | $40000 | $0 | | $40000 |
| 3.127.1 | $0 | $0 | $60000 | | $60000 |
| | $0 | $0 | $0 | | $0 |
| 3.129.1 | $0 | $10000 | $10000 | | $20000 |
| 3.130.1 | $0 | $0 | $15000 | | $15000 |

## 3.129.1 Deformation in Unconsolidated Sediments - New Brunswick

It is proposed to continue collecting data on deformational structures in unconsolidated sediments in the vicinity of seismically active Passamaquoddy Bay and Bay of Fundy area, New Brunswick.

This study is proposed to provide elements of a data base on deformation which is geologically young and which may have a tectonic origin. This study is one of several to be funded under the auspices of the MAGNEC program.

It is anticipated that the results of this study will be helpful in trying to determine if any of the deformational features seen in unconsolidated sediments, along the north shore of the Fundian coast, are due to crustal tectonics.

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|---|---|
| Proponent | J.L. Wallach |
| Evaluator | DRR (Z. Domaratzki) |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | N.B. Department of Natural Resources |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $10K | $10K | $75K | $0K | $95K |

Earlier Directly-Related Contracts and Funding:

| | | | | |
|---|---|---|---|---|
| 3.104.1 | $0 | $40000 | $0 | $40000 |
| 3.127.1 | $0 | $0 | $6000 | $6000 |
| 3.128.1 | $0 | $0 | $20000 | $20000 |
| 3.130.1 | $0 | $0 | $15000 | $15000 |
| 3.131.1 | $0 | $25000 | $25000 | $50000 |

## 3.130.1 Neotectonics in Nova Scotia

It is proposed to collect data on deformational structures in unconsolidated sediments and possibly in bedrock in the Minas Basin of Nova Scotia. The Aspy Fault will also be examined.

This study is proposed to provide elements of a data base on deformation which is geologically young, and which may have a tectonic origin. This study is one of several to be funded under the auspices of the MAGNEC program.

It is anticipated that the results of this study will be helpful in trying to determine if any of the deformational features seen in unconsolidated sediments, along the south shore of the Fundian coast, are due to crustal tectonics. There will also be an attempt to interpret the nature and origin of geologically young movements in the bedrock, such as across the Aspy Fault.

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|---|---|
| Proponent | J.L. Wallach |
| Evaluator | DRR (Z. Domaratzki), SSS (J.L. Wallach) |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | N.S. Dept. of Mines & Energy |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $25K | $25K | $100K | $0K | $150K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 3.104.1 | $0 | $40000 | $0 | | $40000 |
| 3.127.1 | $0 | $0 | $6000 | | $6000 |
| 3.128.1 | $0 | $0 | $20000 | | $20000 |
| 3.129.1 | $0 | $10000 | $10000 | | $20000 |
| 3.131.1 | $0 | $25000 | $25000 | | $50000 |

## 3.131.1 Neotectonic Investigations in Southern Ontario

It is proposed to continue the regional inventory of structural features, begun last year in Prince Edward County. Detailed studies of selected features, suspected of being young and possibly tectonic in origin, will be undertaken by excavating, drilling, surveying and applying ground geophysics. The Consecon Quarry and the Kingsford roadcut, though not in Prince Edward County, are among the specific areas under consideration for investigation.

This study is proposed to increase the knowledge of processes suspected of generating geologically young features as well as to help establish a better understanding of the paleotectonic framework in part of southern Ontario. This study is one of several to be funded under the auspices of the MAGNEC program.

The results of this study will add information to the geological component of the MAGNEC program on neotectonics, which is essential in order to improve the estimate of seismic risk in eastern Canada.

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|---|---|
| Proponent | J.L. Wallach |
| Evaluator | DRR (Z. Domaratzki), SSS (J.L. Wallach) |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | Ontario Geological Survey |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $25K | $25K | $100K | $0K | $150K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 3.104.1 | $0 | $40000 | $0 | | $40000 |
| 3.127.1 | $0 | $0 | $6000 | | $6000 |
| 3.128.1 | $0 | $0 | $20000 | | $20000 |
| 3.129.1 | $0 | $10000 | $10000 | | $20000 |
| 3.130.1 | $0 | $0 | $15000 | | $15000 |

## 3.132.1 Relocation of Seismic Events - Phase 2

It is proposed to continue the work begun last year wherein many earthquakes in southern Ontario and in the West Quebec seismic zone were relocated using two codes: JHD (Joint Hypocenter Determination) and JED (Joint Epicenter Determination). This year efforts will be undertaken predominantly in southern Ontario, though some additional work is anticipated in the West Quebec seismic zone.

This study is proposed to attempt to locate zones, or individual structures, that are in reality seismogenic, but which have, heretofore, not been recognized. This study is one of several to be funded under the auspices of the MAGNEC program.

The results of this study will bear directly on improving seismic hazard estimates because reliable locations of previous seismic events will enable seismologists to do their calculations of seismic wave attenuations from particular locations rather than assuming random sources.

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|---|---|
| Proponent | J.L. Wallach |
| Evaluator | DRR (Z. Domaratzki), SSS (J.L. Wallach) |
| Project Manager | J.L. Wallach |
| Panel | |
| Contractor | A. Mohajer |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $15K | $20K | $65K | $0K | $100K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 3.104.1 | $0 | $40000 | $0 | | $40000 |
| 3.127.1 | $0 | $0 | $6000 | | $6000 |
| 3.128.1 | $0 | $0 | $20000 | | $20000 |
| 3.129.1 | $0 | $10000 | $10000 | | $20000 |
| 3.130.1 | $0 | $0 | $15000 | | $15000 |

## 4.101.1 Study of the Health Effects of Inhaled Uranium Ore Dust

It is proposed to provide funding for the ongoing project to study the health effects (cancer mortality and histological defects) on experimental animals exposed to different concentrations of long-lived radioactive dust, such as those encountered in the uranium mines in Ontario and Saskatchewan.

The study is proposed because Canadian uranium miners are occupationally exposed to long-lived dust (containing uranium, thorium and their long-lived daughters), and the contribution of this exposure to the incidence of cancer is not fully understood.

The results of this study will be used to interpret the health effects of long-lived dust on uranium miners and to develop regulatory guidelines for controlling exposures to long-lived radioactive dust.

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|---|---|
| Proponent | HRS, RPD |
| Evaluator | RPD (F. Horvath) |
| Project Manager | P. Duport |
| Panel | 3 |
| Contractor | MacLaren Plansearch Inc. |
| Principal Investigator | A. Van der Vooren |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $203K | $205K | $260K | $140K | $188K | $996K |

Earlier Directly-Related Contracts and Funding:

## 4.102.1 Review of Techniques Used to Assess Past Exposures to Radon

It is proposed to continue funding the comparison of the techniques used to evaluate past exposures to radon daughters in various uranium and non-uranium mines in Canada and elsewhere.

At present it is not known whether the techniques and assumptions used to estimate past exposures to radon daughters in various Canadian mines, such as those in Newfoundland, Ontario and Saskatchewan, and elsewhere are similar to one another or different. As a result it is difficut to compare the risk estimates obtained from one epidemiological study to another.

The results of the study should enable the AECB to compare and improve the risk estimates obtained from the various epidemiological studies.

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|---|---|
| Proponent | ACRP, HRS, UMD |
| Evaluator | ACRP, RPD |
| Project Manager | P. Duport |
| Panel | |
| Contractor | Senes Consultants Ltd. |
| Principal Investigator | D.B. Chambers |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $12K | $45K | $3K | $0K | $0K | $60K |

Earlier Directly-Related Contracts and Funding:

## 4.103.2 Physical Characteristics and Solubility of Long-Lived Airborne Particulates in Uranium Producing and Manufacturing Facilities

It is proposed to continue funding this project to determine experimentally the size distribution, the activity distribution and the solubility of airborne uranium-bearing aerosols in all Canadian uranium mines and mills, refineries, conversion facilities and fuel fabrication plants.

This work is proposed to quantify the hazard presented by airborne radioactive long-lived materials in the concerned facilities. The parameters (size distribution, activity distribution, radionuclide composition and dissolution rate in simulated lung fluid) which are necessary to calculate the committed effective dose equivalent from exposure data must be determined in order to evaluate quantitatively this specific radiation hazard.

It is anticipated that this study will indicate the magnitude of the risk from long-lived particulates in uranium producing and manufacturing industries. It will also provide supporting information for any forthcoming regulation on long-lived dust and will facilitate interpretation of bioassay data for the purpose of the radiation protection of the workers at these facilities.

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|---|---|
| Proponent | UMD, RPD, FWD |
| Evaluator | UMD, RPD, FWD |
| Project Manager | K.P. Ho |
| Panel | 5 |
| Contractor | MacLaren Plansearch Inc. |
| Principal Investigator | A. Van der Vooren |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $20K | $93K | $117K | $36K | $266K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 84.3.22 | $49000 | $0 | $0 | | $49000 |

## 4.104.1 Radon/Thoron Fluxes in Uranium Mines (Ontario)

It is proposed to continue funding the study to measure the flux of radon and thoron gases emitted per unit surface area of stopes, airways and passageways of an underground uranium mine in Ontario.

The AECB has recently completed a research project (84.3.4) aimed at developing a computer model of underground mine ventilation networks. That model is made up of two parts. The first part of the model is used to determine the patterns of air circulation throughout the mine. The second part is designed to predict the concentrations of short-lived airborne radionuclides at given points of the ventilation network, for radiation protection purposes. The accuracy of those predictions depends on the quality of the information available on the characteristics of the sources of radon and thoron gases.

It is anticipated that systematic and accurate measurement of the characteristics of radon and thoron sources will enable the AECB to use the computer ventilation model to its full capabilities, and to carry out studies and verifications required by the Uranium Mine Division. (See 4.105.1.)

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|---|---|
| Proponent | UMD |
| Evaluator | UMD (D. Corkill) |
| Project Manager | P. Duport |
| Panel | |
| Contractor | Denison Mines Ltd. |
| Principal Investigator | J.L. Chakravatti |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $63K | $40K | $4K | $0K | $0K | $107K |

Earlier Directly-Related Contracts and Funding:

## 4.106.2 Ontario Miners Mortality Study - Update

It is proposed to continue funding the investigation of the cause of excess lung cancer among miners in Ontario, by updating the mortality analysis for Ontario uranium miners for the period from 1981 to 1984 and for gold miners from 1977 to 1984, in order to re-evaluate the risk of lung cancer per unit exposure of radiation.

This project is proposed because there is a need for an extension of the Phase II study (84.8.4) where excess lung cancer among gold miners and the influence of smoking on the incidence of lung cancer among uranium miners were investigated. The Phase II study recommended that the mortality analysis of gold miners should be extended from 1977 to 1984 to evaluate the impact of gold mining experience on the risk estimate for lung cancer among uranium miners.

It is anticipated that the results of the study will be used to improve the risk estimates for radiation-induced lung cancers. (This is a joint project with the Workers' Compensation Board of Ontario and Ontario Ministry of Labour, each of which will contribute $47K to the project over the next two years.)

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| Proponent | UMD, OML, RPD, HRS |
| Evaluator | ACS, UMD, RPD |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | Ontario Ministry of Labour |
| Principal Investigator | |
| Category | 1 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $22K | $25K | $0K | $47K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 84.8.4 | $180000 | $0 | $0 | | | $180000 |

## 4.108.1 Intercomparison of Dust Sampling Instruments

It is proposed to conduct a literature review, followed by laboratory and field intercomparisons of the sampling characteristics of two cascade impactors (the Sierra #210 and the Marple Personal Cascade Impactor) which are used to determine the size distribution parameters of (Activity Median Aerodynamic Diameter (AMAD) and Geometric Standard Deviation (GSD)) aerosols. The objective is to evaluate the accuracy and reliability of the Marple Personal Cascade Impactor (in comparison with the more sophisticated Sierra #210) as a tool for verifying, at frequent intervals, the AMAD and GSD of long-lived radioactive dust in uranium-producing facilities. The adequacy of long-lived dust samples (in terms of the total radioactivity) as measured by a portable cyclone instrument and the CEA Personal Alpha Dosimeter (PAD) will be evaluated against open face and cascade impactor samples.

This project is proposed because the AECB is considering using the combined formula recommended in the ICRP Publication 30 for calculating the Committed Effective Dose Equivalent (CEDE) received by uranium workers. Since the Annual Limit on Intake (ALI) for long-lived dust is a function of the AMAD of the aerosols, it is necessary, in order to calculate the radiation doses due to the inhalation of long-lived dust, to know the total concentration of radioactivity in the air and the AMAD of the dust. Personal cyclones provide a measure of the dust particles in the size range from 0.5 micron to 5 microns, but neglect particles smaller than 0.5 micron and larger than 5 microns, which also contribute to the radiation dose. The fraction of the total dust collected by cyclones depends upon the AMAD and GSD of the total size distribution. The CEA-PAD provides a measure of the total radioactive dust concentrations but has not been evaluated for this purpose in Canadian facilities. In order to obtain the information necessary for determining individual radiation doses due to exposure to long-lived dust, it is therefore necessary: a) to determine the suitability and reliability of a personal cascade impactor, which will be used to verify the AMAD and GSD of long-lived dust at the work place; and b) to assess to what extent dust samples, collected with portable cyclones and the CEA-PADs, are affected by variations of the AMAD and GSD of the dust, and what impact variations of these parameters may have on dose calculations.

It is anticipated that this study will indicate whether the Marple Personal Cascade Impactor can be used for routine determination of the AMAD and GSD of long-lived radioactive dust in uranium mines and mills, how variations in the AMAD and GSD of the dust affect sampling characteristics of portable cyclones and CEA-PADs, and how variations of these parameters should be taken into account to calculate the doses attributed to long-lived dust from dust measurements taken with personal cyclones and CEA-Personal Alpha Dosimeters.

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| Proponent | UMD, RPD |
| Evaluator | UMD, RPD |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $60K | $30K | $0K | $90K |

Earlier Directly-Related Contracts and Funding:

## 4.109.1 Measurement of the Unattached Fraction with Wire Screens

It is proposed to continue funding the study to calibrate, experimentally, in the laboratory, a variety of wire screen aerosol collectors for measuring the unattached fraction of radon and thoron progeny in air. In addition, the theory and the semi-empirical laws governing aerosol collection and alpha counting characteristics on wire screen collectors will be developed.

This project is proposed because the complete deposition of the unattached fraction of radon and thoron progeny in the respiratory tract delivers 10 to 20 times more energy per unit mass of tissue than the attached fraction present in the atmosphere. The unattached fraction of radon and thoron daughters is highly variable, ranging from a few percent in diesel-powered areas of uranium mines, to more than 40% in non-mechanized areas and surface installations. Consequently, a complete evaluation of the radiological hazard presented by airborne radioactivity requires the knowledge of the unattached fraction. Wire screen aerosol collectors are the most convenient tools for measuring the unattached fraction; however, the characteristics of their collection efficiency and counting geometry have not been thoroughly investigated.

It is anticipated that the results of the study will fill a gap in knowledge regarding the accuracy of a crucial parameter in the measurement of ultrafine radioactive aerosols. They will also allow Board staff to interpret more accurately airborne radioactivity measurements taken in uranium-producing facilities.

| | |
|---|---|
| Proponent | HRS, RPD |
| Evaluator | RPD |
| Project Manager | P. Duport |
| Panel | |
| Contractor | University of Toronto |
| Principal Investigator | C.R. Phillips |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $22K | $50K | $18K | $0K | $0K | $90K |

Earlier Directly-Related Contracts and Funding:

## 4.110.1 Modified Personal Alpha Dosimeter for Uranium Mines

It is proposed to continue funding the modification of the measuring head of the personal alpha dosimeter developed by the French Atomic Energy Commission and used in some Canadian uranium mines and mills.

The modification is aimed at eliminating, or reducing substantially, spurious measurements of airborne radon and thoron decay products induced by the contamination of the internal parts of the measuring head by ultrafine long-lived radioactive dust particles.

It is anticipated that the modification, if it proves successful, will significantly improve the accuracy and reliability of individual exposure measurements to airborne radioactivity in high grade uranium mines and mills in Saskatchewan. (The Department of Energy, Mines and Resources has agreed to a contribution of $10K for FY 86/87 in addition to the AECB contribution for FY 86/87 shown below.)

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|---|---|
| Proponent | CAIRS, HRS, UMD |
| Evaluator | UMD, RPD |
| Project Manager | P. Duport |
| Panel | |
| Contractor | Canadian Institute for Radiation Safety |
| Principal Investigator | E. Becker |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $18K | $7K | $28K | $0K | $0K | $53K |

Earlier Directly-Related Contracts and Funding:

## 4.111.2 Uranium Mine Radiation Safety Course

It is proposed to continue to fund the Uranium Mine Radiation Safety Course (UMRSC). This continuing twice-a-year course sponsored by the AECB has been given since 1976.

This course is designed to provide participants with the basic understanding of radiological hazards to workers and to the environment. It also presents practical approaches to deal with these hazards. The philosophy and regulatory approach of the AECB are discussed.

It is anticipated that this course will provide a better understanding of uranium mine radiation safety principles to mine supervisors, inspectors and operations personnel, and to representatives from regulatory agencies, mining companies and unions, who are directly involved in uranium mine radiation safety. (The cost, proposed for FY 88/89, is composed of the following: contract $55K; DSS charges $1K; AECB staff travel $19K.)

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|---|---|
| Proponent | UMD |
| Evaluator | UMD (J. Viljoen) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | Canadian Institute for Radiation Safety |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $154K | $50K | $75K | $0K | $0K | $279K |

Earlier Directly-Related Contracts and Funding:

## 4.112.1 Electrical Charge of Radioactive Aerosols in Uranium Mines

It is proposed to measure the fraction of positively and negatively charged aerosol particles carrying radon and thoron daughters, to determine the number of elementary charges carried by individual charged particles, and to relate these parameters to the ionization conditions and carrier aerosol parameters that prevail in underground uranium mine atmospheres.

The radiation dose delivered to the lung from inhaled radon and thoron daughters depends upon the deposition of these radioactive particles in the respiratory tract, which in turn depends on the size distribution and electrical charge of these particles. The aerosol size distribution itself is governed in part by the electrostatic attraction between ultrafine radon and thoron daughters and carrier aerosol particles generated by mining activities and diesel engines. Owing to the ionization induced by relatively large concentrations of alpha radiation emitters, the consequent phenomena (collectively referred to as "atmospheric electricity") play an important role in shaping the resulting radioactive aerosol actually inhaled by miners. To date, no study has been carried out in Canadian mines to determine the electrical properties of airborne radon and thoron daughters.

It is anticipated that the findings of this study will, for the first time, bring information to the AECB staff on the electrical state of radioactive aerosols in mines. This information may also be used in interpreting monitoring and dosimetry data and may serve to complement the computer modelling of mine atmospheres.

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| Proponent | EMR (J. Bigu), HRS |
| Evaluator | RPD |
| Project Manager | P. Duport |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $60K | $30K | $0K | $90K |

Earlier Directly-Related Contracts and Funding:

## 4.113.1 Tracer Gas Method for Assessing Ventilation Efficiency

It is proposed to identify and test a tracer gas technique that is suitable for measuirng ventilation rates in underground uranium mines and mills. Phase I of the work includes identifying portable, rugged, and easy-to-use equipment that can function in underground mines and in mill environments, and that allows several measurements to be made in a short period of time. Phase II includes the acquistion and testing of the equipment at selected sites in a mine and mill.

This project is proposed because, in the performance of inspections of uranium mines and mills, AECB inspectors have encountered a number of situations where measurement of air flow directions or flow rates (for the purpose of evaluating the radiation protection efficacy of the ventilation system) has been difficult. Recent advances in the use of tracer gas techniques may be able to overcome the difficulties involved in performing these measurements in currently troublesome ventilation situations.

It is anticipated that a suitable tracer gas method (and related equipment) would permit AECB inspectors to evaluate more quickly and accurately the efficacy of ventilation systems of mine and mill licensees.

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| Proponent | UMD |
| Evaluator | UMD, RPD |
| Project Manager | P. Duport |
| Panel | |
| Contractor | CANMET, EMR |
| Principal Investigator | J. Bigu |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $25K | $35K | $0K | $0K | $60K |

Earlier Directly-Related Contracts and Funding:

## 4.115.1 Dissolution Rates of High Grade Uranium Ore Dust from Saskatchewan

It is proposed to determine the in vitro dissolution rate, in simulated lung fluid, of high grade uranium ore dust, the bulk ore having been obtained from a Saskatchewan mine (approximately 40% uranium ore grade), and ground to a dust of various diameters in the micron range. Radionuclides to be investigated are U-238, Th-230, Ra-226 and Pb-210. Particular emphasis is to be placed on early dissolution rates following immersion of the uranium ore dust in simulated lung fluid.

The AECB is in the process of conducting a research project to investigate the carcinogenicity of inhaled uranium ore for individual organs and tissues of the rat in the project entitled "Study of the Health Effects of Inhaled Uranium Ore Dust", 3.101.1. Information is needed on the rates at which various radionuclides are translocated from lung to other organs and tissues, to enable initial dose calculations to be performed and chemical toxicity effects to be predicted.

The results will be of direct use in the design of the experiment utilizing rats inhaling similar high grade uranium ore dust. The in vitro dissolution rates are required as input data prior to the initiation of preliminary animal experiments.

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| Proponent | RPD |
| Evaluator | RPD (F.J. Horvath) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | Becquerel Laboratories |
| Principal Investigator | R. Robertson |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $13K | $14K | $0K | $0K | $27K |

Earlier Directly-Related Contracts and Funding:

## 4.116.1 Remote Control and Automation in Heavy Industry

It is proposed to conduct a literature review of the applications of remote control techniques and robotics in the mining industry, with an emphasis on mining and maintenance equipment. The study will also include a survey of remote control and robotic equipment currently in use in other heavy industries. The study will be international in scope and provide a brief overview of typical installations and their viability, including technical documentation, whenever available as well as the names and addresses of suppliers of such equipment.

The review is proposed because the development of high-grade uranium operations in Western Canada will necessitate an assessment, by the AECB, of state-of-the-art applications of such equipment, to minimize worker exposure to radiation. The study will indicate trends, successes and shortcomings in the application of this equipment, and identify facilities in which this equipment was or is still in service, and will provide the AECB with an up-to-date list of suppliers and relevant operating data.

It is anticipated that the study will provide AECB staff with the necessary information to assess to what extent the uranium mining companies, which are operating on high grade ore, are utilizing current technology in order to optimize their radiation protection practices.

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| Proponent | UMD |
| Evaluator | UMD (R. McCabe) |
| Project Manager | P. Duport |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

## 4.117.1 Evaluation of Long-Lived Dust Exposures from Silica Samples

It is proposed: a) to assess, from the available literature, to what extent dust samples (collected in Canadian uranium mines for the purpose of determining exposures to silica dust) are suitable for evaluating individual exposures to long-lived dust with an accuracy accceptable to the AECB; b) if warranted by the results of a), to determine experimentally the correlation between the mass of quartz collected (on total or respirable dust samples) and the alpha activity emitted by the long-lived radionuclides embedded in the dust particles; c) to determine the suitability and sensitivity of silica dust measurements for determining individual exposures to long-lived dust; and d) to evaluate the cost-effectiveness of the technically-acceptable monitoring method(s).

The implementation of the Proposed General Amendments to the Atomic Energy Control Regulations will require that each and every radiation hazard present in the work place be taken into account for the determination of individual exposures. In the case of the uranium mining and milling industry, this will require in particular that individual exposures to airborne long-lived dust be evaluated and entered together with gamma, radon daughter and thoron daughter exposures, into a formula from which individual doses and commited effective doses will be calculated. At present, there is no method used routinely in Canadian mines that is known to be able to provide reliable information on long-lived dust exposure. However, silica (or quartz) concentration in mine atmospheres is monitored routinely because of the risk to mine workers of silicosis. It is useful to study to what extent dust samples collected for silica monitoring are suitable for evaluating individual exposures to long-lived dust. In the event these samples are not suitable for evaluating individual exposures to long-lived dust with the required accuracy, alternate methods, such as random spot sampling and the use of personal integrating monitors should be tested in order to determine the most cost-effective technique to be used to meet the upcoming regulatory requirements.

It is expected that this study will indicate to the AECB whether current silica dust samples can be used to evaluate individual exposures to long-lived dust in uranium mines and mills. In the event these samples are found to be unsuitable for this purpose, the study will indicate the most cost-effective method to be used to meet the regulatory requirements.

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| Proponent | HRS, UMD |
| Evaluator | UMD (B. Smart) |
| Project Manager | P. Duport |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $25K | $0K | $75K |

Earlier Directly-Related Contracts and Funding:

## 4.118.1 Evaluation of Exposure Records of Eldorado Uranium Miners

It is proposed to re-examine the radon daughter exposure records and work histories of a number of uranium miners who worked at the Beaverlodge Mine (of the then Eldorado Nuclear Limited) in Saskatchewan for the period from 1952 to 1983, and who may have had previous exposures to radon daughters at other mines.

There is some concern about the accuracy of the exposure estimates used in recent epidemiological studies of the Beaverlodge uranium miners. Therefore it has become necessary to re-examine the exposures of individual miners, taking exposures received in other mines and work histories into account.

It is anticipated that the results of this study will be used with other specific epidemiological studies, of miners exposed to radon daughters, to improve risk estimates for lung cancer.

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| Proponent | UMD, RPD |
| Evaluator | UMD (B. Smart) |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $55K | $0K | $0K | $55K |

Earlier Directly-Related Contracts and Funding:

## 4.119.1 Evaluation of Mine Ventilation Monitoring Devices

It is proposed to identify the devices that are currently available for continuous and instantaneous sampling of air velocity. A side-by-side comparison will be undertaken of accuracy, reliability and ruggedness of representative devices when these devices are subjected to environmental conditions similar to those found in underground uranium mines and in mills.

This study is proposed because ventilation systems used to reduce the radioactive contamination in mine and mill air must be maintained at their optimal performance, requiring continuous auditing by mine and mill staff. Some types of the traditional mechanical air velocity-and-pressure-measuring equipment are becoming obsolete and are being replaced by electronic devices. Information on the operating capabilities of modern devices, and their ability to provide accurate and reliable data when used in the cold, damp, dusty environments of underground uranium mines, and dusty atmospheres of uranium mills, is required by the UMD to assess the radiation protection methods used by licensees.

It is anticipated that the results of this study will enable the UMD to prepare a regulatory guideline, for use throughout the uranium mining industry, for the measurement of air volumes.

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| Proponent | UMD |
| Evaluator | UMD (D. Corkill) |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $35K | $0K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

## 4.120.1 Sensitivity of Bronchial Epithelial Cells to Alpha Radiation

It is proposed to investigate, by means of a search of the literature (human and animal data) and discussions with researchers currently active in the field, the sensitivities of bronchial epithelial cells to alpha radiation of energies of 8 MeV and below. The investigation will focus on the production of chromosome aberrations in cells and on induction of lung cancer.

This study is proposed because the process of inducing lung cancer in humans by exposure to alpha radiation (such as is believed to occur in uranium miners) is not well understood. The cells of the bronchial epithelium which, upon absorption of alpha energy, initiate the development of lung cancer have not been identified with certainty.

It is anticipated that the findings of this study (i.e., information that is currently available and directions for future studies) will provide information that is pertinent to understanding the mechanism of lung cancer induction by radiation.

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| Proponent | RPD, Sask. Dept. of Labour, HRS |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $20K | $0K | $0K | $20K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 4.121.1 | $31000 | $58000 | $28000 | | | $117000 |

## 4.121.1 Measurement of the Thickness of Bronchial Epithelium

It is proposed to continue support for the project to measure the depth of basal cells and the thickness of cilia and mucous layers covering the human epithelium of the tracheo-bronchial region, to identify the cells that make up the epithelial walls, and to indicate their relative number in the cell population. Measurements of the various parameters will be made on biopsy and autopsy samples.

The study is expected to improve the accuracy of the various anatomical parameters used in lung dose calculations. Currently available data on the above anatomical parameters are based only on a single study which is known to have many uncertainties.

It is anticipated that the more accurately determined parameters obtained from this study will be used in the calculation of lung doses due to inhaled radon and thoron daughters and long-lived radioactive dust.

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| Proponent | RPD, HRS |
| Evaluator | RPD (F. Horvath, C. Pomroy) |
| Project Manager | E. Rabin |
| Panel | 7 |
| Contractor | University of Manitoba |
| Principal Investigator | D.H. Bowden |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $31K | $58K | $28K | $0K | $0K | $117K |

Earlier Directly-Related Contracts and Funding:

## 4.122.1 Use of Moss and Lichens for Passive Air Monitoring - Literature Review

In view of the possibility that licensees may propose to replace or diminish the present active monitoring program in favour of a passive system, it is proposed to conduct a review and critical evaluation of the scientific and technical literature concerning the use of mosses and lichens as passive air monitoring tools.

At present information concerning the use of passive air monitoring is fragmented. This project would draw together all available information in order to provide AECB staff with a view of the current state of knowledge and technology involved in passive air monitoring.

The information gained from this project would provide AECB staff with a global view of the proposed technique. In addition the project would provide specific information concerning the technique of passive monitoring of radionuclides. This information would be used in evaluting any proposals concerning passive air monitoring made by licensees.

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| Proponent | WMD |
| Evaluator | WMD (R.J. Maloney) |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 5.110.2 Measurement of Thorium Concentration in Fish: A Field Study

In areas where uranium mine tailings contain significant amounts of pyrite, thorium isotopes may be remobilized and, therefore, move into the environment. It is proposed to undertake a field study to deterine the concentration of these radionuclides in fish and their associated water and sediments.

The AECB recently commissioned a review of the scientific literature (86.4.7) to determine the extent and quality of information concerning the uptake of U-nat, Ra-226, Th-232, Th-230, and Th-228 by fish. Preliminary results of the survey show that a lot of data exist on the uptake of uranium and radium. If the review confirms that information on thorium is sparse there will be a need to carry out a field study.

The information from this project would be used to determine whether thoriums should be included in the calculation of release limits for effluents from uranium mines and mills.

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| Proponent | WMD |
| Evaluator | WMD (B. Zgola) |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $45K | $0K | $0K | $45K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 86.4.7 | $25000 | $0 | $0 | | | $25000 |

## 5.111.1 Effective Communication with the General Public

A project is proposed to identify problems involved in communicating to the general public the technical information associated with the disposal of radioactive waste. Problems of misconceptions, which social issues to include in discussions, what the public expects of regulators in terms of responsibilities and information to be provided, etc., are to be considered. This study would be done in two phases. Phase I would consist of identifying material and concerns to be addressed with emphasis on those to be addressed in a regulatory context. Phase II would, from the regulatory perspective, address the findings of Phase I.

In June 1977, the governments of Canada and Ontario responded to concerns of the public and the nuclear industry by initiating a program "to dispose of radioactive waste from nuclear power reactors" safety in a deep, underground repository in intrusive igneous rock. AECL and OH were given responsibility for research. Subsequently in August 1981 the Canada-Ontario joint statement announced, inter alia, that the AECB would be the lead agency for the regulatory review of a ten-year Nuclear Fuel Waste Management Program to examine the feasibility of deep geological disposal for high level waste, a "concept assessment" of a "disposal system", prior to any actions related to disposal.

The project would: a) better prepare AECB staff for participaton in forthcoming public hearings; and b) enhance the ability of AECB staff to understand and communicate regulatory requirements and may identify the need for additional requirements.

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|---|---|
| Proponent | WMD |
| Evaluator | WMD (K. Bragg) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $15K | $10K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 5.115.1 Software Quality Assurance for Waste Disposal Models

It is proposed to survey the latest developments in quality assurance programmes for software as applied to modelling. The survey would identify the best applicable methods for assuring the quality of software systems to be applied to nuclear waste disposal.

AECB staff will be required to assess licence submissions concerning the predicted performance of existing and proposed nuclear waste disposal facilities. Some of these performance predictions will be generated by software modelling packages currently under development by industry and government agencies. Confidence that all of the requirements associated with model design, development and testing have been identified and implemented, is dependent on the effectiveness of the software quality assurance programme.

The results of the survey will assist AECB staff in assessing the effectiveness of the quality assurance programme to be applied to a particular model and hence the degree of confidence associated with how the model will perform.

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| Proponent | CQAD, WMD |
| Evaluator | CQAD (D. Scrimger), WMD (P. Flavelle) |
| Project Manager | D.E. Connelly |
| Panel | 12 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 5.118.1 Coupled Processes in the Assessment of Deep Disposal

It is proposed to acquire an appropriate computer code with which to study the behaviour of a hypothetical waste disposal vault in plutonic rock. The vault would be assumed to be subject to natural and engineered conditions resulting from its location and from the emplacement, within it, of irradiated fuel. Thermal, mechanical and hydrological mechanisms, acting in different combinations, will be assessed.

This study is proposed to help provide a better understanding of the nature of the processes controlling mass transport from high-level repositories in crystalline rock. In particular, it is hoped to determine whether the coupling of thermal, mechanical and hydrological mechanisms would contribute substantially to being able to accurately predict radionuclide migration. It is also planned to be able to determine which mechanisms, when coupled, have the greatest effect.

The results of this study will assist the Waste Management Division in preparing for its review of the documents to be received at the conclusion of the Concept Assessment phase of the Canadian Nuclear Fuel Waste Management Program.

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| Proponent | WMD (S. Nguyen, P.A. Flavelle) |
| Evaluator | WMD (S. Nguyen, P.A. Flavelle) |
| Project Manager | J.L. Wallach |
| Panel | 10 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $80K | $0K | $0K | $80K |

Earlier Directly-Related Contracts and Funding:

## 5.119.1 Uncertainty in the Interpretation of Hydrogeologic Data

It is proposed to undertake an independent and critical review of the hydrogeological data obtained at the Atikokan site by AECL for the Concept Assessment phase of the Canadian Nuclear Fuel Waste Management Program. It is also planned to analyze and assess the interpretations made of the data and to examine alternative interpretations. The study is being conducted in order to assess the impact of: a) errors in measurement and data manipulation; b) different interpretations of hydrogeologic data; and c) different models in characteristic underground flow systems.

This study is proposed to help the AECB conduct an independent assessment of high-level waste disposal and to ensure that methods and reviews of modelling and databases used within the high-level waste program are internally consistent.

The results of this study will assist the AECB in reviewing the document to be submitted at the conclusion of the Concept Assessment phase of the Canadian Nuclear Fuel Waste Program.

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|---|---|
| Proponent | WMD (P.A. Flavelle) |
| Evaluator | WMD (P.A. Flavelle) |
| Project Manager | J.L. Wallach |
| Panel | 10 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $40K | $0K | $0K | $40K |

Earlier Directly-Related Contracts and Funding:

## 5.120.1 Factors Affecting Mobility of Ra-226 in Groundwater - Review

It is proposed to initiate a literature search and critical evaluation of the scientific literature concerning the effect of the components of pore water on the migration of Ra-226 through tailings.

The migration of radionuclides from tailings through unconsolidated material occurs in a complex system of solutes, colloids and suspended particles. Tailing material not only consists of ground rock but also of the chemicals used in the milling process. The chemicals are disposed of with the ground ore and is usually called raffinate. The type of chemicals and the amounts used vary with the type of ore being milled. This mixture produces a very complex pore water. At present, the contribution of the components of this material to the migration of radionuclides is only accounted for in a very simplistic fashion. It is not clear that this is an appropriate treatment.

The results of this project would be used in evaluating the models submitted ot the AECB in such documents as conceptual decommissioning plans, and application for operating licences.

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| Proponent | WMD |
| Evaluator | WMD (R.J. Maloney), RPD |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 5.121.1 Calibration/Validation of FEMWATER/FEMWASTE on the Nordic Site

It is proposed to: a) compile the existing groundwater monitoring data (1979-1984) for the Nordic tailings site; b) set up a preliminary model with FEMWATER/FEMWASTE in order to define gaps in input values and actual field information; c) define a program for field and laboratory work based on the outcome of tasks a) and b) above (soil samples would be taken to determine hydraulic conductivities and retardation factors, and additional groundwater samples might be required in order to update the movement of contaminant plumes); and d) set up a final model with FEMWATER/FEMWASTE in order to calibrate and validate the model prediction with the actual field data.

Doses from abandoned uranium tailings sites are predicted using pathway analysis system models (such as UTAP). These models are generally probabilistic and require numerous runs; thus each pathway in the model is reduced to its simplest expression. Contaminant transport in groundwater systems proves to be the major pathway in most situations. FEMWATER/FEMWASTE is a finite element program that models the groundwater pathway in much greater detail than any system model. Although FEMWATER/FEMWASTE is highly regarded in the hydrology community, it has yet to be applied and validated on specific tailings sites.

The results of this study would enable AECB staff to demonstrate the applicability of FEMWATER/FEMWASTE to actual tailings sites and to obtain a calibrated, validated tool to independently assess licensee applications for the decommissioning of uranium tailings sites and also for low-level waste sites.

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| Proponent | WMD |
| Evaluator | WMD (S. Nguyen, W. Napier), RPD |
| Project Manager | R. Avadhanula |
| Panel | 11 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $80K | $0K | $0K | $80K |

Earlier Directly-Related Contracts and Funding:

## 5.122.1 Application of UTAP to the Bancroft Area - A Field Study

It is proposed to assess the radiological impact of the Bancroft area Dyno, Bicroft and Madawaska mine/mill wastes on the local environment and public. The Uranium Tailings Application Program (UTAP) will be used in this assessment and it may be necessary to collect considerable field data in order to satisfy the input requirements of UTAP. It is proposed that this be a jointly funded project with the Ontario Ministry of the Environment, the Federal Department of Energy, Mines and Resources, and the Atomic Energy Control Board as partners.

A local organization, the Paudash Conservation Association, has been expressing concern with the above-mentioned wastes for several years. Early in 1986, the Association retained CAIRS to produce an overview report of the waste situation. This report has been completed and indicts the regulatory process in Canada. It raises many questions regarding the impact of these wastes on the public and the environment. Some of the local residents have circulated a petition addressed to the provincial and federal governments requesting action, particularly at the idle Dyno and Bicroft properties. An independent review of the situation is required to allay or confirm the fears of the local public.

Results of this study would provide AECB staff: a) an independent review of the radiological impact of the Bancroft area uranium mine/mill wastes; and b) further testing and demonstration of UTAP.

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| Proponent | WMD |
| Evaluator | WMD (B. Zgola, G. Jack) |
| Project Manager | R. Avadhanula |
| Panel | 11 |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $25K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 5.124.1 An Evaluation of Contaminant Retardation Mechanisms

It is proposed to examine and evaluate conceptually, theoretically and mathematically, the effects of different contaminant retardation mechanisms on the prediction of radionuclide migration from an engineered, underground waste disposal vault towards the biosphere.

This study is proposed to assess the consequences of: a) attributing contaminant retardation to a particular mechanism when it may not be the correct or the only mechanism; and b) ignoring the factors controlling the mechanism(s) when making predictions about contaminant migration based on experimental data.

The results of the study will assist AECB staff to review the document to be submitted at the conclusion of the Concept Assessment phase of the Canadian Nuclear Fuel Waste Program.

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| Proponent | WMD (P.A. Flavelle) |
| Evaluator | WMD (P.A. Flavelle) |
| Project Manager | J.L. Wallach |
| Panel | 13 |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $0K | $0K | $30K |

Earlier Directly-Related Contracts and Funding:

## 6.102.1 Radiation Doses to Technologists from Radiotherapy

It is proposed to measure and compare the radiation doses received by radiotherapy technologists during performance of their duties on two different types of treatment machines (high energy accelerators and cobalt 60 machines). The aim of the project is to determine: a) the doses received by technologists working on cobalt 60 and high energy linear accelerators (>20 MeV); b) the dose uniformity amongst technologists (since the dose results from the "head" of the machine which is normally above the technologist, the dose to the upper part of the body could be significantly higher than to the waist area where the TLD badge is often worn); and c) the contriubtions to the exposure from working inside the treatment room during the setting up of patients and from working at the control console of the machine.

This work is proposed because, in order to reduce the radiation exposure received by technologists in a radiotherapy department, it is necessary to identify the significant sources of exposure and their relative magnitudes. Also, the radiation exposures attributed to technologists may vary from machine to machine implying that there may be significant differences in exposure at the various machines.

It is expected that the proposed research will provide information on the relative exposure received by technologists working on the different types of therapy machines From this information, the AECB may be able to infer the mechanism by which the technologists receive the major part of their personal exposures. This information is essential in order to effect changes aimed at reducing personal radiation exposures, including the re-assignment of pregnant technologists to those duties where exposure is minimized as well as to develop protocols aimed at reducing the radiation exposure to the technologists.

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| Proponent | RTD |
| Evaluator | RTD (W.R. Brown), OCRF (A. Guilbaud) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 6.103.1 Beta-Gamma Counting of Ra-228/Ac-228 in Urinalysis

It is proposed to fund a project to determine experimentally the feasibility of using beta-gamma counting of Ra-228/Ac-228 as a means of routine urinalysis for thorium.

This project is being proposed because, while there are several dozen workers (e.g., thorium mantle workers and uranium mill workers in Elliot Lake) occupationally exposed to thorium, present urinalysis measurements for thorium are done by colourimetric analysis whose sensitivity is about 20 micrograms/L, which is inadequate for a routine bioassay program for thorium.

It is anticipated that the results of this study will determine whether the proposed beta-gamma counting for Ra-228/Ac-228 can provide significant improvement in sensitivity over the present chemical process (i.e. colourimetric analysis) and also whether the proposed beta-gamma counting method can be used for a routine bioassay program.

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| Proponent | RPD |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $0K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 6.104.1 Production of a Hospital Radiation Safety Officer's Handbook

It is proposed to continue the funding to produce a handbook for use in Canadian hospitals by the hospital Radiation Safety Officer (RSO).

This work is proposed because the AECB has recently amended the policy regarding the uses of radionuclides in hospitals and has restated the role of the RSO. As a result, the certification of Registered Technologist of Nuclear Medicine (RTNM) is now considered as sufficient proof of competence for a RSO position.

It is anticipated that the production of this handbook will be used as a reference manual by Radiation Safety Officers and that the manual will contain diverse technical and regulatory information useful in the daily activities of a RSO. (This project will be funded jointly with DSS. Their contribution will be provided in FY 87/88 and it is to be 50% (approximately $15K) of the project cost; the AECB will contribute the remaining 50% in FY 88/89 for a total project cost of approximately $30K.)

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| Proponent | RTD |
| Evaluator | RTD; RPD |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | Canadian Radiation Protection Assoc. |
| Principal Investigator | W. Spiers |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 6.105.1 Radiation Exposures of Non-Monitored Hospital Personnel

It is proposed to continue the funding to study the radiological impact of nuclear medicine patients on non-monitored hospital staff. The nuclear medicine patients are those who have had radioisotopes administered to them for the purpose of diagnostic medical examinations. The non-monitored hospital staff of interest in this study are workers who handle or are near nuclear medicine patients during the performance of their duties and who are not monitored for radiation exposures. Examples of these workers are ultrasound technicians, nurses and receptionists in nuclear medicine departments. Three university hospitals will be participating in this project and they are: Institut de Cardiologie de Montreal, Hotel Dieu de Montreal, and Hopital Laval de Quebec. This project has been requested by the union representing the nurses at these hospitals and this project also has the support of the management at each of the participating hospitals.

This study is proposed because there is a scarcity of information on radiation exposures for these specific job categories within hospitals. In order to assess doses and to verify whether the ALARA principle is being observed, the magnitude of exposures to these categories of workers should be known.

It is anticipated that the proposed research will provide information on the radiation doses and dose rates received by the various job categories. From the information obtained in this study, the AECB should be able to develop guidelines to reduce the radiation exposures, according to the ALARA principle, to non-monitored hospital staff. (This project will be jointly funded with DSS as follows: for FY 87/88 $30K by DSS and for FY 88/89 $41K by AECB.)

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| Proponent | RTD |
| Evaluator | RTD (M. Simard), RPD (G. Poirier) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | Institut de Cardiologie de Montreal |
| Principal Investigator | L. Renaud |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $41K | $0K | $0K | $41K |

Earlier Directly-Related Contracts and Funding:

## 6.106.1 Evaluation of Berthold LB1200 & BICRON MicroRem Survey Meters

It is proposed to extend the evaluation of the Berthold LB1200 survey meter performance characteristics (Project 85.6.3) to include alpha detection capability and additional gamma and beta ray response characteristics. In addition it is proposed to perform a comprehensive evaluation of the performance characteristics of the BICRON MicoRem survey meter that takes into account the influence of ambient environmental conditions found in the field.

This study is proposed because radiation survey meters used in on-site inspections of licensees' facilities are frequently subjected to harsh environmental conditions. The LB1200 is the principal field survey meter used by AECB inspectors to assess compliance of licensees' operations with AEC Regulations and licence conditions. With reference to the BICRON survey meter, the presently used low dose rate survey meters (PRM7 and Macphar) are to be phased out. CSLD staff are assessing the market for a replacement instrument and have purchased one BICRON survey meter for evaluation. A thorough evaluation of the performance characteristics of this instrument would prove of immediate value to CSLD staff, as to whether the BICRON is well suited to their needs.

It is anticipated that the results of this study will provide AECB inspectors with a detailed understanding of the capabilities and limitations of these instruments when used in harsh conditions encountered in the field.

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| Proponent | CSLD |
| Evaluator | CSLD |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $20K | $0K | $0K | $20K |

Earlier Directly-Related Contracts and Funding:

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|---|---|---|---|---|---|---|
| 85.6.3 | $18013 | $0 | $0 | | | $18013 |

## 7.101.1 The Canadian National Dose Registry Study

It is proposed to continue funding the project to conduct an epidemiolgical study of cancer mortality among some 300,000 Canadians occupationally exposed to low levels of ionizing radiation, by developing a suitable linkage between the Canadian National Dose Registry and the Canadian Mortality Data Base.

This study is intended to find out whether there is any excess cancer mortality among certain groups of workers, such as Nuclear Medicine Technicians and Radiographers, who have not been studied so far in sufficient detail. This study of 300,000 radiation workers is likely to provide further information towards a better understanding of the dose-response relationship for low doses of ionizing radiation.

It is anticipated that the results of this study will be used to verify risk estimates for radiation-induced cancer mortality. (This is a joint study with the Department of National Health and Welfare and Statistics Canada. NHW has expended considerable resources both in dollars and person-years in support of this project. The expenditure by NHW (estimated to be $1,211K) is in addition to the funds expended by the AECB.)

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| Proponent | NHW (P. Ashmore), HRS, Statistics Canada (M. Fair) |
| Evaluator | RPD (M. Measures) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | Statistics Canada |
| Principal Investigator | M. Fair |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $169K | $50K | $70K | $35K | $0K | $324K |

Earlier Directly-Related Contracts and Funding:

## 7.105.1 Epidemiological Study of Radiation-Induced Developmental Defects

It is proposed to continue funding the pilot epidemiological study of teratogenic (non-inherited) defects among Canadians who received in utero irradiation. (Cancer is not considered to be a developmental defect.)

With the revision of dose limits for female atomic radiation workers, increasing numbers of young women are expected to seek employment in the nuclear industry and in other activities where exposure of an embryo or fetus may occur. This exposure may result in increased incidence of radiation-induced developmental defects. The currently available risk estimate of one-tenth per Sv for developmental defects has a number of uncertainties associated with it and, therefore, further studies are needed. No comprehensive epidemiolgoical study has ever been undertaken in Canada to obtain this additional information which would improve the risk estimates for radiation-induced developmental defects.

It is anticipated that the results of the study will enable the AECB to determine the feasibility of a full-scale study. Such a full-scale study, if it is feasible, is likely to result in the improvement of risk estimates for radiation-induced developmental defects.

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| Proponent | RPD, HRS |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | V. Elaguppillai |
| Panel | 1 |
| Contractor | University of British Columbia |
| Principal Investigator | T.W. Anderson |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $25K | $33K | $4K | $0K | $0K | $62K |

Earlier Directly-Related Contracts and Funding:

## 7.106.2 Effects on Central Nervous System from In Utero Exposure

It is proposed to fund a full-scale study of the health effects on the central nervous system (CNS) of experimental animals (rats and monkeys) following in utero exposure to ionizing radiation at different stages of gestation.

It is anticipated that an increasing number of young women will seek employment in the Canadian nuclear industry, where, in some cases, exposure of embryos or fetuses may occur. Very little information is available in the literature about the effect of in utero irradiation on the function and structure of the central nervous system. A feasibility study (84.8.8) completed in 1986 recommended a full-scale study to make quantitative estimations of the risk of health defects on the CNS following in utero irradiation taking dose, dose rate, and the stage of gestation into account. The Review Panel is also awaiting the results of 7.105.1 from which neuro-histological information (from humans) is needed in order for the present study to commence.

The results of the full-scale study will be used to improve risk estimates for radiation-induced developmental defects.

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| Proponent | RPD, HRS |
| Evaluator | RPD (F. Horvath) |
| Project Manager | V. Elaguppillai |
| Panel | 1 |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $100K | $100K | $100K | $300K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 84.8.8 | $22000 | $0 | $0 | | | $22000 |

## 7.109.1 Epidemiological Study of Genetic Disorders in Adults

It is proposed to continue funding the epidemiological study of genetic disorders among adults in British Columbia. Genetic disorders among a cohort of nearly 20,000 persons born before 1952 will be analyzed using the most recent classification codes.

This study is complementary to the earlier British Columbia study of childhood genetic defects among a cohort of nearly 60,000 individuals born between 1952 and 1982. The earlier AECB-funded study was completed in FY 85/86 with the recommendation that adulthood genetic defects among those born prior to 1952 should also be investigated to minimize any bias of underestimating the risk of radiation-induced genetic defects.

It is anticipated that the results of the study will improve the risk estimates for radiation-induced genetic disorders.

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| Proponent | RPD, HRS |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | University of British Columbia |
| Principal Investigator | T.W. Anderson |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $49K | $7K | $15K | $0K | $0K | $71K |

Earlier Directly-Related Contracts and Funding:

## 7.110.1 Screening of Human Populations for Abnormal Radiosensitivity

It is proposed to continue funding the project which is intended to develop a relatively inexpensive and rapid assay to screen for inherited differences in radiosensitivity of individuals.

This project was proposed because in recent years, there has been "increasing recognition that there are human genotypes that confer both increased cancer risk and abnormal cellular sensitivity on exposure to carcinogenic agents, including ionizing radiation". Subgroups of human populations possessing these genotypes affect the distribution of risk. Depending on the degree of heightened sensitivity, the average dose-response relationship may significantly underestimate the risk for low dose or low dose-rate exposure of the sensitive individuals. The carriers of the "defective" genotypes are often not identifiable by common clinical tests. An ability to detect such persons on an occupation-wide basis could lead to improved protection for radiation workers and greater comprehension of how risk is distributed. An appreciable side-benefit could accrue from the practical application of such a screening assay: persons identified as "normal" would be somewhat less at risk than was previously supposed. The principle of such an assay currently exists in the cultured fibroblast, colony-forming ability assay. However, the fibroblast assay is too labour-intensive and expensive (estimated cost approximately $5,000 per strain (assay procedure) to test for sensitivity to ionizing radiation) to be used in screening large numbers of persons, and additionally too slow (establishment of the primary culture and survival analyses can take 6 to 8 months).

It is anticipated that the results of this study will lead to a technique for routine screening for inherited differences in radiosensitivity of subpopulations of radiation workers and others. Information obtained from routine screening of these subpopulations may impact upon the exposure-risk estimates currently forming the basis for the AECB occupational limits for exposure to ionizing radiation, owing to a necessary re-evaluation of the distributions of risk derived from epidemiological studies. (This is a joint study with AECL on an equal cost-sharing basis.)

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| Proponent | RPD, HRS |
| Evaluator | RPD |
| Project Manager | E. Rabin |
| Panel | 8 |
| Contractor | Atomic Energy of Canada Limited - CRNL |
| Principal Investigator | N. Gentner & D. Morrison |
| Category | 1 * |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $75K | $114K | $83K | $0K | $0K | $272K |
| Earlier Directly-Related Contracts and Funding: | | | | | | |
| 7.110.2 | $0 | $0 | $2320 | | | $2320 |

## 7.111.1 In Vitro and In Vivo Studies of the Effects of Ionizing Radiation on the Developing Central Nervous System

It is proposed to continue funding the in vitro and in vivo studies of the effects of exposure to external gamma radiation on the developing central nervous system of rat and monkey embyos, using whole embryo culture.

It is anticipated that an increasing number of Canadian women will seek employment in the nuclear industry where, in some cases, exposure of embryos or fetuses may occur. Although mental retardation has been found to be the major developmental defect among those who received in utero exposure in the nuclear bomb explosions in Japan, very little information is available in the literature about the effect of radiation on the function and structure of the brain. This study will help in the understanding of the problem.

It is anticipated that the results of the study will assist in the quantification of the risk of an in utero exposure to ionizing radiation on the developing central nervous system. (The University of Manitoba and the Children's Hospital Research Foundation of Manitoba will contribute $160K to the project over the three years. In addition, a DSS contribution of $60K from its Unsolicited Proposal Fund was received for the year 1987/88. NHW also committed $10K for this project.)

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| Proponent | RPD, HRS |
| Evaluator | RPD (F. Horvath) |
| Project Manager | V. Elaguppillai |
| Panel | 1 |
| Contractor | University of Manitoba |
| Principal Investigator | T.V. N. Persaud |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $78K | $18K | $0K | $96K |

Earlier Directly-Related Contracts and Funding:

## 7.116.1 Cancer Morbidity Follow-Up Feasibility Study

It is proposed to determine the feasibility of using morbidity data sources available in Canada for individual medical follow-up studies by attempting to link the National Dose Registry with the Alberta Cancer Registry and to determine any association between occupational radiation exposure levels and cancer incidence. This would be a first step toward potential future use of the National Cancer Data Base. It is further proposed to use a case-control methodology in which groups of individuals are selected based on whether or not they have the disease, in this instance, as determined from the Alberta Cancer Registry.

This feasibility study is proposed because morbidity data will greatly assist the AECB in determining whether any excessive health effects or risks exist due to exposure to certain potentially hazardous environmental, occupational or other factors. This information will both complement and supplement mortality data available through the Canadian Mortality Data Base by providing a more sensitive measure (than mortality data alone) of the differences in risk from exposure to potentially hazardous environmental, occupational or other factors and a possible earlier detection of any potential health hazard. It will allow for earlier preventive measures to be introduced in the workplace for current as well as future employees.

It is anticipated that this study will provide the AECB with: (i) the ability to draw upon more cancer data from Canadian sources; and (ii) the opportunity to detect the occurrence of any non-fatal or rare cancers. In addition, it will assist the AECB in identifying areas of occupational, environmental, and other health risks for the general public and will aid the AECB in its regulatory activity, and finally, will help in providing information for the assessment of exposures and occupational hygiene practices.

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| Proponent | Statistics Canada (M. Fair), HRS |
| Evaluator | RPD |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $30K | $20K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 7.117.1 Hospital Record-Keeping System for Epidemiological Studies

It is proposed to conduct a feasibility study to modify hospital record-keeping systems to facilitate inexpensive case-control epidemiological studies of radiation-induced cancers.

Case-control studies of radiation-induced cancer can be conducted inexpensively using hospital records. However, the record-keeping systems in Canadian hospitals are not currently in a format to facilitate such studies.

It is anticipated that the results of the study will determine the *feasibility* of modifying hospital record-keeping systems to facilitate epidemiological studies. If the modification is feasible, several epidemiological studies of radiation-induced health effects can be conducted inexpensively to improve the corresponding risk estimates.

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| Proponent | RPD, HRS |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | V. Elaguppillai |
| Panel | 2 |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $0K | $0K | $50K |

Earlier Directly-Related Contracts and Funding:

## 7.118.1 Selection of Control Groups for Epidemiological Studies

It is proposed to fund the development of a unified system of selecting control groups for use in epidemiological studies of radiation-induced health effects.

One of the major problems in interpreting the results of epidemiological studies of groups exposed to ionizing radiation is the general lack of comparability between different studies of similar groups. The main source of the problem is the variation of the quality of control groups used in the different studies. It is therefore essential to develop a comprehensive system or methodology for selecting control groups for use in Canadian epidemiological studies of radiation-induced health effects. Lack of uniformity in selecting control groups has also been recognized as a weakness in epidemiological studies in other countries.

It is anticipated that the results of this study will provide a unified system or methodology of selecting control groups for use in epidemiological studies of radiation-induced health effects.

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| Proponent | RPD, HRS |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | 2 |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $45K | $0K | $0K | $45K |

Earlier Directly-Related Contracts and Funding:

## 7.119.2 Full-Scale Epidemiological Study of Thyroid Cancer from I-131 Exposure

It is proposed to continue funding the epidemiological study of thyroid cancer among Canadians who were exposed to radioactive iodines during diagnostic examinations.

This project is proposed because risk estimates for radiation-induced thyroid cancer are largely based on the incidence among those exposed to X-radiation. There is some controversy as to whether or not the same doses of I-131 and X-radiation are equally effective for the induction of thyroid cancer. A pilot study (84.8.13), jointly funded by the Alberta Cancer Board and the AECB, recommended a full-scale study at the national level to investigate the relative biological effectiveness of X-radiation and I-131.

The results of the study are expected to refine the risk estimates for radioiodine-induced thyroid cancers, and to determine whether or not equal (thyroid) doses of I-131 and X-radiation are equally effective in the induction of thyroid cancers. (This is a joint study with the ten provincial cancer registries, each contributing $50K, and the Department of National Health & Welfare which will contribute $271K to the project over the next two years.)

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| Proponent | RPD, HRS |
| Evaluator | RPD (F. Horvath) |
| Project Manager | V. Elaguppillai |
| Panel | 2 |
| Contractor | G.B. Hill Statistics Inc. |
| Principal Investigator | G.B. Hill |
| Category | 1 * |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $40K | $60K | $50K | $0K | $150K |

Earlier Directly-Related Contracts and Funding:

| | | | | | |
|---|---|---|---|---|---|
| 84.8.13 | $61000 | $0 | $0 | | $61000 |

## 7.121.1 Cancer Mortality among Cardiac Catheterization Patients

It is proposed to continue funding a feasibility study of cancer mortality among nearly 3000 patients who were exposed to ionizing radiation during cardiac catheterization at the Hospital for Sick Children in Toronto during the period 1946-1965.

There have been reports suggesting an excess in the incidence of leukemia, breast and thyroid cancers among those who received exposures, as children, to low doses (50 - 300 mSv) of X-radiation during cardiac catheterization. No comprehensive epidemiological study has ever been undertaken to examine the relationship between the radiation exposures and the cancer mortality among those patients.

The results of this study will be used to improve the AECB's understanding of the dose-response relationship at low doses of ionizing radiation. At the end of this feasibility study, and depending on the adequacy of the results obtained, a full-scale study at the national level may be undertaken to improve the accuracy of the risk estimates derived from the feasibility study. (This is a joint project with the National Cancer Institute of Canda and the Ontario Cancer Treatment and Research Foundation (OCTRF) and the Hospital for Sick Children, Toronto, which will contribute jointly $65K to the project over the next two years.)

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|---|---|
| Proponent | RPD, OCTRF (A. Clarke), HRS |
| Evaluator | RPD (C. Pomroy) |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | Ontario Cancer Treatment & Research Fnd. |
| Principal Investigator | A. Clarke |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $15K | $35K | $20K | $0K | $70K |

Earlier Directly-Related Contracts and Funding:

## 7.122.1 Computerized Linkage of National Cancer Incidence Data

It is proposed to develop a satisfactory format for the computerized record linkage of national cancer incidence data with personal identifiers of breast and lung cancer patients who were previously exposed to fluoroscopic radiation during pneumothorax examination for tuberculosis.

The reason for proposing a cancer incidence linkage is to identify cancers which have occurred in the cohorts, but which have not been the underlying cause of death, and therefore have not been identified in the usual mortality linkage. This approach has never been used in any epidemiological studies of persons exposed to ionizing radiation.

The results of this study will help to determine whether the occurrence of a particular type of radiogenic cancer in any way yields a different mortality pattern for the same cancer, arising from a non-radiogenic cause. This study may have an impact on the risk estimates which form the basis of the dose limits for ionizing radiation. (This is a joint project with National Cancer Institute of Canada and Statistics Canada, which will jointly contribute $100K to the project over the next three years.)

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| Proponent | RPD, NCIC (G. Howe), Statistics Canada, HRS |
| Evaluator | RPD |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $60K | $60K | $0K | $120K |

Earlier Directly-Related Contracts and Funding:

## 7.126.1 Use of An Employee Identification Questionnaire and Guide

It is proposed to fund a project which is intended to promote the use of the employee identification questionnaire and the user guide developed and tested in the project entitled "Standardization of Individual Identifying Information for Health Record Keeping Methodology" (7.108.1). With information collected in Phase II (of 7.108.1) which identifies the potential users for this questionnaire, methods will be selected for advising Canadian companies and agencies, as well as international agencies and committees with occupational health record keeping requirements, of the questionnaire with a view to encouraging its use.

This project is proposed, in particular, because the derived information is intended to be targeted at AECB licensees who are required to implement and maintain health record systems and who supply information on radiation doses to the National Dose Registry.

It is anticipated that the results of the study will facilitate and encourage adequate on-going individual record keeping for the preparation of current and past employee nominal rolls. In addition, it may form the basis of an unambiguous identification of the individual in conjunction with the collection of radiological and non-radiological exposure histories and work histories. These will allow for subsequent follow-up, by the AECB, of health outcomes (mortality, morbidity, and genetic effects), and will be of use for reporting purposes to registries (dose, exposure and disease), and for other legislative or regulatory requirements.

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| Proponent | Statistics Canada (M. Fair), HRS |
| Evaluator | RPD |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 7.108.1 | $0 | $57000 | $21000 | | | $78000 |

## 7.127.1 Dose Response of Human Lymphocytes to Radiation and Chemical Carcinogens

It is proposed to investigate the feasibility of using a flow cytometry method for measuring radiation damage in fresh (recently extracted) human lymphocytes, and to measure the damage produced by a combined exposure to radiation, delivered at doses in the occupational range, and to chemical carcinogens.

This project is proposed because currently there is uncertainty as to whether radiation and chemical insults act synergistically, independently, or whether the chemical carcinogens influence a cell's response to radiation insult. This project is intended to be an appropriate follow-on to 7.107.1, "A Feasibility Study on the Identification and Determination of Exposure Levels of Non-Radiological Carcinogenic Substances at Canadian Nuclear Facilities", as it will provide experimental evidence of synergism or lack thereof.

It is anticipated that the findings of this study will assist AECB staff in quantifying the modifying influences of chemical carcinogens on the responses of workers to occupational radiation exposure. (This project is proposed to be funded jointly with AECL. AECL and the AECB will each contribute 50% of the cost of the project for a total of $146K.)

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| Proponent | RPD, HRS |
| Evaluator | RPD |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| | $0K | $0K | $48K | $25K | $0K | $73K |

Earlier Directly-Related Contracts and Funding:

| | | | | | | |
|---|---|---|---|---|---|---|
| 7.107.1 | $0 | $41000 | $5000 | | | $46000 |

## 7.128.1 The Relative Impact of Radiation-Induced Genetic Disorders

It is proposed to fund a study to determine the relative impact of different types of radiation-induced serious genetic disorders in terms of their respective loss of years of life expectancy by linking the B.C. Health Surveillance Registry Records with the Canadian National Mortality Data Base.

The study is proposed because the relative impact of different types of serious genetic disorders can only be compared on a common scale, such as in terms of their respective loss of years of life expectancy. To date, no comprehensive study has been done to derive the relationship between different types of genetic disorders and their respective loss of years of life expectancy in the Canadian context. The data base at the B.C. Health Surveillance Registry is considered to be a leading source in North America for such a complex analysis. Initiation of this study is awaiting the results of 7.109.1.

It is anticipated that the results of the study will enable the AECB to compare, on a common scale, the relative impact of different types of radiation-induced genetic disorders. (This is proposed to be a joint study with B.C. Ministry of Health and Statistics Canada, with AECB contributing 70% of the total cost.)

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| Proponent | RPD, UBC (S. Sheps), Statistics Canada (M. Fair) |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| | Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|---|
| - | $0K | $0K | $45K | $45K | $0K | $90K |

Earlier Directly-Related Contracts and Funding:

## 7.130.1 Ionizing Radiation in Tumour Promotion or Progression

It is proposed to determine whether ionizing radiation, delivered chronically to tissue, acts as a tumour-promoting or -progressing agent for chemically-initiated carcinogenesis. This animal study will be carried out on mice using beta irradiation of the skin.

This study is proposed because ionizing radiation has been tested only as an agent for cancer initiation, the first step in the multi-step carcinogenesis model. It has been demonstrated to be a skin tumour-initiating agent when irradiated cells were subsequently chronically exposed to a chemical tumour-promoting agent (phorbol ester). The action of radiation in the other two steps of carcinogenesis (promotion and progression) has not been tested, however. The possibility that ionizing radiation acts as a tumour-promoting agent is particularly relevant because of recent evidence implicating oxidizing free radicals as the chemical promoters of tumours. These free radicals are the same DNA-damaging species as are produced by ionizing radiation. This point is also particularly important to the Canadian nuclear industry. Skin is an organ which is constantly in contact with the environment, and human skin undoubtedly contains cells which are "initiated" as a result of DNA damage from chemicals, sunlight or previous ionizing radiation. Atomic Radiation Workers are chronically exposed to low doses of radiation. If ionizing radiation acts as a tumour-promoting agent, then chronic exposure would stimulate the initiated cells to form tumours. Such a mechanism would also apply to cells elsewhere in the body which may be in the initiated state and could be chronically exposed to radiation. Lung is another organ likely to contain initiated cells resulting from exposure to environmentally generated hydrocarbons, and is also subject to chronic exposure to radon gas. Similar concerns also apply to the possibility that ionizing radiation may act as a progressing agent. Recent evidence has indicated that the risk of a benign tumour progressing to a malignant carcinoma can be substantilly increased if the tumour is exposed to DNA damaging chemicals. Most mature humans have a variety of non-malignant skin tumours, most of which have a very low risk of progression to carcinomas. However, if chronic exposure to ionizing radiation causes sufficient DNA damage, the risk of progression of these tumours may be substantially increased.

It is anticipated that the results of this study of ionizing radiation as a tumour promoter or progressor will impact on risk assessments for atomic radiation workers and other workers who are chronically exposed to industrial or medical processes where radiation sources are used. (The study is proposed to be funded jointly by the AECB and AECL on an equal cost sharing basis: AECB $85K, AECL $85K.)

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| Proponent | RPD |
| Evaluator | RPD |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $76K | $9K | $0K | $85K |

Earlier Directly-Related Contracts and Funding:

## 7.131.1 MOSFET or Silicon Diode Based Personal Beta Dosimeters

It is proposed to determine: a) the feasibility of using MOSFET (Metal Oxide Semi-Conductor Field Effect Transistor) radiation detectors or silicon diodes to measure beta doses to the skin of individuals; and b) the suitability (i.e. sensitivity, ruggedness, etc.) of such devices for personal beta dosimetry.

This study is proposed because the Canadian intercomparison of thermoluminescent dosimeters, carried out by the Working Group on External Dosimetry at several nuclear reactor sites in Canada, found variations in skin dose measurements that could not readily be explained. The Working Group recommended that further research directed towards developing a beta dosimeter for shallow dose measurements be undertaken.

It is anticipated that the results of this study will lead to the development of a beta dosimeter capable of providing improved estimates of shallow skin dose. (This study is proposed to be funded equally by the AECB and AECL. The estimated total cost of the study would be about $52K; the AECB contribution would be about $26K. The work is proposed to be undertaken by AECL-CRNL.)

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| Proponent | RPD |
| Evaluator | RPD (G. Poirier) |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $17K | $9K | $0K | $26K |

Earlier Directly-Related Contracts and Funding:

## 7.132.1 Computerized Format for Pooling Radiation Exposure Records

It is proposed to transform the records of past exposures to both radiation and other carcinogens into a computerized format. Initially, the study will be confined to exposure records of Atomic Radiation Workers in Canadian nuclear power stations.

There is an increasing need for an international standardization of radiation exposure records to facilitate pooling of data for follow-up studies of persons occupationally exposed to relatively low doses of ionizing radiation. International experts agree that the data from various countries should be pooled together and analyzed comprehensively in order to arrive at more statistically significant risk estimates for radiation-induced cancers. Since Canada is a leader in mortality surveillance programs involving nuclear power station workers, upgrading of the data base into a universal computerized format is very appropriate.

The results of this study will enable the AECB to pool the exposure data of Canadian nuclear power station workers with similar data from other countries, and facilitate more comprehensive risk estimates for radiation-induced cancers and other effects.

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| Proponent | RPD, HRS, UBC (T.W. Anderson) |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $45K | $30K | $0K | $75K |

Earlier Directly-Related Contracts and Funding:

## 7.133.1 Bone Cancer from Radionuclide Intake

It is proposed to conduct an epidemiological study of bone cancer incidence among Canadian children and young adults exposed to radium and other bone-seeking radionuclides in drinking water and food. In the first phase of the study, radium and other bone-seeking radionuclides in typical milk and food samples, obtained from areas where well water is used for irrigation purposes, will be measured. In a subsequent phase, a detailed case-control study of bone cancer incidence, in relation to total radium and other radionuclide intake, will be investigated.

A preliminary study of bone cancer incidence among Ontario residents has identified a suggestive association between the incidence of excess bone cancer and exposure to concentrations of radium in well water higher than the provincial average, which does not include the Great Lakes as a source of drinking water. Although the level of radium in the well water of all bone cancer cases was less than the NHW-recommended maximum concentration of 1 Bq/L, the total intake of radium and other radionuclides, mainly dietary intake, should be measured to derive a relationship between the total intake of these radionuclides and the incidence of bone cancer.

The results of this study are expected to provide a quantitative relationship between excess bone cancer and total radium and other radionuclides intake. (This is expected to be a joint study with NHW, Ontario Ministry of Labour, Ontario Ministry of the Environment and the Ontario Cancer Treatment and Research Foundation at a total cost for both phases of $900K, of which the AECB portion would be about $120K, approximately $60K of which is expected to be for Phase I and the balance for Phase II.)

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| Proponent | RPD, OCTRF, OML |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $40K | $40K | $40K | $120K |

Earlier Directly-Related Contracts and Funding:

## 7.134.1 Threshold Effect of CNS Defects Due to In Utero Exposure

It is proposed to investigate, in a laboratory study, whether or not there exists a threshold effect for defects on the developing central nervous system (CNS) following in utero exposure to low doses of ionizing radiation, by measuring the ratio of brain to body weight of a suitable animal (newborn) as a function of doses received in utero.

Recent findings of the study of A-bomb survivors in Hiroshima and Nagasaki seem to suggest the possibility of the existence of a threshold for radiation-induced defects on the developing central nervous system, at very low doses. The results of some animal studies have also raised the possibility of the existence of a threshold for defects on the central nervous system for doses between 50-100 mSv received in utero. These findings are in disagreement with the assumed linear dose effect relationship for radiation-induced defects on the CNS.

The results of the study will be used to resolve the controversy about the existence of a threshold effect for radiation-induced defects on the central nervous system. In addition, the results will be used to improve the radiation protection practices for female Atomic Radiation Workers in Canadian nuclear facilities and radioisotope laboratories. (This is expected to be a joint study with the University of Texas, U.S. National Institutes of Health, and the Atomic Energy Control Board. The total cost of the study is about $275K, with an AECB contribution of $80K.)

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| Proponent | RPD, U. of Texas (W. Schull), HRS |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | 1 |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $80K | $0K | $0K | $80K |

Earlier Directly-Related Contracts and Funding:

## 7.135.1 Mechanism of Radiation-Induced Mental Retardation

It is proposed to conduct a laboratory study to investigate the effect of in utero exposure to low doses of ionizing radiation on the migration characteristics of neurons from periventricular zones to the cerebral cortical zone of the brain of non-human primates, as a function of in utero dose, using the tritium-labeled thymidine autoradiographic technique.

A recent analysis of the Japanese A-bomb survivors' data indicates an increased incidence of mental retardation among children exposed in utero during the nuclear explosion. It is now thought (ICRP 49) that a major mechanism for the observed mental retardation is impaired neuronal migration due to radiation exposure. It is therefore important to understand the mechanism of the radiation-induced mental retardation, and the dose-response relationship for the impairment of neuronal migration in non-human primates.

The results of the study will improve the understanding of the mechanism of radiation-induced mental retardation, and the dose-response relationship for impairment of neuronal migration. (This is expected to be a joint study with the University of Texas (Houston), Yale University (New Haven) and the AECB. The total cost of the project is about $650K, and the AECB share is $220K for the entire period of the study. The initiation of this project is dependent upon the successful completion of the project "Threshold Effect of CNS Defects Due to In Utero Exposure", 7.134.1.)

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| Proponent | RPD, U. of Texas (W. Schull), Yale U. (P. Rakic), HRS |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | 1 |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $20K | $60K | $140K | $220K |

Earlier Directly-Related Contracts and Funding:

## 7.136.1 Confounding Factors Associated with Breast Cancer Incidence

It is proposed to investigate the interaction between low-LET radiation and confounding factors such as smoking, dietary constituents and intake of drugs and hormones, on the incidence of breast cancer among women exposed to X-rays during fluoroscopic examination.

The currently used risk estimates for radiation-induced breast cancer are subject to a number of uncertainties because of inadequate accounting of the presence of confounding factors such as smoking, certain dietary constituents and intake of drugs and hormones. The National Cancer Institute of Canada has accumulated large quantities of data on these confounding factors as a result of their previous study of breast cancer associated with fluoroscopic examination. These data should be analyzed to evaluate the influence of the various confounding factors on the incidence of breast cancer.

The results of this study are likely to identify the confounding factors and their influence on breast cancer incidence and are likely to improve, ultimately, the risk estimates for radiation-induced breast cancer.

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| Proponent | RPD, NCIC (G. Howe), HRS |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $45K | $0K | $0K | $45K |

Earlier Directly-Related Contracts and Funding:

## 7.137.1 Study of Childhood Cancer following Maternal X-Irradiation

It is proposed to investigate the incidence of childhood cancer among (i) those children who had abnormal delivery (such as breech presentation) or birth defects (such as Down's Syndrome), but whose mothers were not subjected to irradiation during pregnancy, and (ii) those who received in utero exposure to X-rays, both groups in comparison with suitably selected control populations.

Some controversial studies have indicated an association between maternal exposure to low doses of ionizing radiation and the incidence of excess childhood cancers. On the other hand, some recent studies have reported an association between abnormal pregnancy cases (such as breech presentation and Down's Syndrome) and excess childhood cancers, even in the absence of exposure to X-rays during pregnancy or delivery. It is therefore possible that the reported association between maternal irradiation and excess childhood cancer was essentially due to those cases of abnormal pregnancies and deliveries and not necessarily due to maternal irradiation on the incidence of childhood cancer.

The result of this study will improve our understanding of the qualitative association between childhood cancer and maternal irradiation and may improve the quantitative risk estimates for radiation-induced cancers.

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| Proponent | RPD, UBC (T.W. Anderson), HRS |
| Evaluator | RPD |
| Project Manager | V. Elaguppillai |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $45K | $20K | $0K | $65K |

Earlier Directly-Related Contracts and Funding:

## 8.101.1 Doses to Road Transport Workers from Radioactive Materials

It is proposed to measure, over a defined period of time, the doses received by a selected subpopulation of road transport workers. The measurements are to be correlated with the type of radioactive material present in the appropriate shipments. Dose estimates are to be based on personal dosimetry measurements wherever possible; otherwise, the calculated doses will be based on realistic exposure models.

This work is proposed because there are indications that some road transport workers may be receiving exposures which would require their classification as Atomic Radiation Workers. Other incidents point to a need for a comprehensive assessment of the exposures received by road transport workers whose employers are not AECB licensees.

It is anticipated that this work will result in the identification of problem areas (with respect to radioactive materials) in the road transport industry and in improvements in the compliance and regulatory system. It will also contribute to the IAEA database on risk assessment with respect to road transport workers. (The project is to be funded by Transport Canada, administered by the Atomic Energy Control Board, and supplied with dosimetry services by the Department of National Health and Welfare. The project cost will be approximately $98K.)

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| Proponent | RTD, Transport Canada |
| Evaluator | RTD (G.B. Johnston) |
| Project Manager | E. Rabin |
| Panel | |
| Contractor | MacLaren Engineering Inc. |
| Principal Investigator | B. Lawrence |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $0K | $0K | $0K | $0K |

Earlier Directly-Related Contracts and Funding:

## 8.102.1 Evaluation of Absorbent Material for Type A Containers

It is proposed to: a) evaluate the parameters which govern the effectiveness of absorbent materials used in Type A containers for the transport of radioactive isotopes; and b) develop standard test procedures and criteria for selecting absorbent material with the optimum combination of parameters.

The packaging regulations require the use of absorbent material in Type A packages containing liquid. Information on the effectiveness of absorbent material is required to permit the evaluation of compliance with the regulations. In addition, guidelines which address the parameters affecting the performance of absorbent materials would help designers of Type A liquid packages, and consignors, to better comply with the regulations, thereby minimizing the consequences of incidents involving this type of package.

The results of the project would assist AECB staff in assessing compliance with packaging regulations with respect to Type A liquid packages.

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| Proponent | RTD |
| Evaluator | RTD (P. Eyre) |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $45K | $0K | $0K | $45K |

Earlier Directly-Related Contracts and Funding:

## 8.103.1 Testing of Foam Used in Packaging for Shock and Thermal Absorbency

It is proposed that samples of polyurethane foam, both cast in situ and from block, be tested for: a) energy absorption; b) load/deflection; and c) thermal resistance. Foams of different densities and from different manufacturing processes will be tested. It is expected that the load/deflector tests would be performed statically, but energy absorption should take into consideration dynamic loading.

Over the last decade there has been considerable use of polymer foam in the construction of packaging for radioactive material. This foam is used in three basic applications, these are: impact limitation, thermal insulation, and moisture absorption. Foam is often made "in situ", filling fully closed cavities that exist in the structure. It is also supplied in bulk blocks and shapes. By alterations in materials, catalyst quantities and processes, it is possible to obtain a foam with certain required properties. Little information is available on the controlling parameters and the resulting properties. This makes difficult the enforcement of quality assurance of packaging by AECB staff.

From the results of these tests, AECB staff would be able to more accurately assess information supplied supporting applications for package and device approval. In addition, manufacturing controls can be determined with which to obtain the necessary level of quality assurance.

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| Proponent | RTD |
| Evaluator | RTD (D. Joseph) |
| Project Manager | R. Avadhanula |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $35K | $0K | $0K | $35K |

Earlier Directly-Related Contracts and Funding:

## 9.102.1 Review of Crisis Management Methods

It is proposed to continue a review of AECB operations and corporate planning and, based on the latest developments in crisis management, to determine which elements of crisis management should be included in corporate planning, and in the preparation of a crisis management manual.

Although there are AECB documents that deal with emergency response at the working level (e.g. duty officer's handbook, divisional operating procedures), there is no corporate document that deals with broader questions such as: - the establishment of a crisis team; - communications with the public, who handles it, and how? - chain of command in the absence of someone in the management structure; - interaction with other government agencies; - role of the AECB Emergency Response Coordinator.

The results of this review will assist AECB staff in updating corporate planning to address crisis management, and in preparing a detailed crisis management manual.

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| Proponent | EXEC |
| Evaluator | DFC (W.D. Smythe), PCS (T. Viglasky, T. Diamantstein) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 2 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $25K | $0K | $0K | $25K |

Earlier Directly-Related Contracts and Funding:

## 9.103.1 Study of the AECB Long Range Plan for Information Management

It is proposed to determine the technical feasibility and to design and prepare a plan for its implementation for the period March 1989 to 1993 of the AECB's strategy for document management, outlined in AECB "Strategic Plan for Information Management 1986-1991". Factors that will be taken into account for the technical feasibility and practicality of the "Strategic Plan for Information Management" include current and projected technologies, worker acceptance of the new technologies, legal issues and interface with external information providers to AECB.

This work is proposed because the AECB's long-term objectives for information management, particularly for the management of documents, represent a very significant departure from traditional practices. A detailed study of the technical feasibility and practicality of the "Strategic Plan for Information Management" must be established prior to the proposed implementation of the plan projected to take place during fiscal years 1989 to 1993.

The results of this project will enable the AECB to confirm the direction it will be taking on information management and to implement the long-range plan for information management.

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| Proponent | IMS |
| Evaluator | ADD (J. Waddington), IMS (W. Goodwin) |
| Project Manager | D.E. Connelly |
| Panel | |
| Contractor | Stevenson Kellog Ernst & Whinney |
| Principal Investigator | |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $73K | $77K | $0K | $0K | $150K |

Earlier Directly-Related Contracts and Funding:

## 9.104.1 Regulatory Effectiveness Measurement System

It is proposed to investigate the feasibility of a Regulatory Effectiveness Measurement System (REMS) to determine what has to be measured in order to show how effective the AECB is in carrying out its regulatory mandate. This is to be achieved by defining what information (in general terms) is needed as an input to the AECB decision-making process to produce a comprehensive data model, and by defining the outputs of the model that would be used to evaluate the preferred process for decision-making. In addition, a prototype system for a typical area of interest (e.g. impact of the AECB program on the nuclear industry's safety record) is to be included as part of the scope of the study.

This study is being proposed recognizing the Government's initiatives to downsize the Public Service and to improve the management of regulatory programs, such as that of the AECB which costs approximately $23 million annually. The Government's initiatives will require increased efforts by the AECB to improve its productivity and ensure effectiveness of its activities. At the moment, for example, there is little evidence to correlate the safety record of the nuclear industry to AECB activities.

It is anticipated that the results of this project will demonstrate the feasibility of a high level management information system which could provide AECB senior management with an early warning system for potential problems and help to ensure the effective use of resources.

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| Proponent | ADD |
| Evaluator | ADD (J. Waddington), IMS (W. Goodwin) |
| Project Manager | K.P. Ho |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 3 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $50K | $100K | $0K | $150K |

Earlier Directly-Related Contracts and Funding:

## 9.105.1 The Relationship between Liability and Behaviour

It is proposed to fund a contract to examine the relationship between the care with which people execute jobs, or operate and manage potentially dangerous installations and liability for which they may be held, should an incident occur which harms members of the general public. It has been proposed that the cost of the project be borne by interested parties other than the AECB.

The project is prompted by litigations against the Attorney General of Canada which questions the constitutional validity of the Nuclear Liability Act. Expert evidence is required which would address the issue of "care versus liability" which has been raised in that litigation.

The results of the contract may be used by the Attorney General of Canada in the litigation.

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| Proponent | LSU |
| Evaluator | LSU (P. Barker) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 * |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $0K | $0K | $0K | $0K |

Earlier Directly-Related Contracts and Funding:

## 9.106.1 Review of the AECB Unified Compensation Plan

It is proposed to fund a contract to review the AECB's Unified Compensation Plan.

The Unified Compensation Plan (UCP) was set up in 1981, and has not been reviewed since its implementation. It appears from the study by the Maintaining Dynamism Group that the UCP plan is a prime source of dissatisfaction by AECB staff members. The staff appears to believe that significant anomalies exist in the classification system. An independent review would supply valuable input for future AECB evaluations of the UCP.

The results of the contract would be used in the preparation of a document which presents and explains the current status of development of the UCP.

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| Proponent | PC(J. Waddington) |
| Evaluator | J. Waddington |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 2 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $15K | $0K | $0K | $15K |

Earlier Directly-Related Contracts and Funding:

## 9.107.1 The Risk of Serious Incidents at Nuclear Power Plants

It is proposed to fund a contract to review the literature on the risk of serious incidents at nuclear power plants. The review would compile and collate the information on both the probability and consequences of serious incidents. It has been proposed that the cost of the project be borne by interested parties other than the AECB.

The project is prompted by litigation against the Attorney General of Canada which questions the consitutional validity of the Nuclear Liability Act. Expert evidence is required which would address the issue of the risk posed by nuclear installations, which has been raised in that litigation.

The results of the contract may be used by the Attorney General in the litigation.

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| Proponent | LSU |
| Evaluator | LSU (P. Barker) |
| Project Manager | D.J. Martin |
| Panel | |
| Contractor | |
| Principal Investigator | |
| Category | 1 |

| Past | 87/88 | 88/89 | 89/90 | Future | Total |
|---|---|---|---|---|---|
| $0K | $0K | $0K | $0K | $0K | $0K |

Earlier Directly-Related Contracts and Funding: